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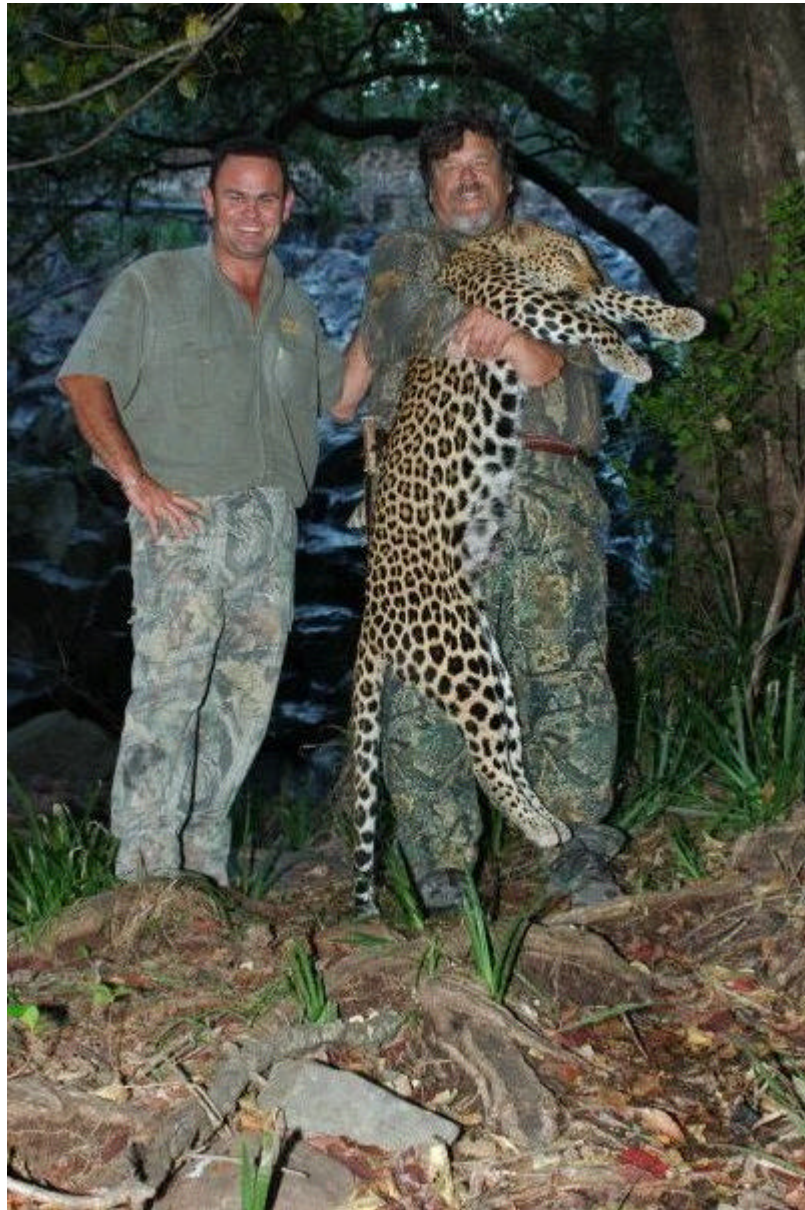
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*Leopard population dynamics, trophy hunting
and conservation in the Soutpansberg Mountains,
South Africa*



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Department of Anthropology
May 2011

**Thesis submitted to Durham University for the degree of Doctor of
Philosophy**

Abstract

This thesis represents a highly novel attempt to combine capture-recapture camera trapping, GPS telemetry and dietary analysis with anthropological techniques such as participant observation and semi-structured interviews in order to investigate leopard population density and dynamics, human-leopard conflict and the potential and effectiveness of trophy hunting as a conservation tool for leopards in the Soutpansberg Mountains, Limpopo Province, South Africa.

Results from camera trapping data show that the Soutpansberg is home to a very high density of leopards (20 per 100km²). This is supported by the small home range of an adult female measured during the study (13.9 km² 95% MCP) suggesting the Soutpansberg is a prey rich area with prey densities high enough to allow leopards to live in large numbers and hold small home ranges. The dispersal movements of a collared sub-adult male indicate that the Soutpansberg may be acting as a population source for sinks beneath the mountains. High levels of human-wildlife conflict exist between leopards and landowners and leopards are frequently persecuted for perceived livestock predation although no evidence of livestock was found in leopard scats.

Trophy hunting does not currently work as an effective conservation tool for leopards by providing economic incentives for landowners to reduce illegal hunting and tolerate the wider leopard population. Quotas are not based on accurate population figures of leopards from field studies, females are allowed in hunting off-take and only game farmers that own hunting farms apply for trophy hunting permits. Landowners responsible for the majority of leopard mortalities (cattle and community farmers) do not conduct trophy hunting due to their distrust of the complex and bureaucratic application process. The sustainability of trophy hunting must be improved by basing off-take on accurate population numbers, monitoring harvested populations, encouraging a wider uptake of commercial hunting and reducing illegal harvests.

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1: Introduction

1.1 The leopard

The leopard, (*Panthera pardus*), is one of the most widely distributed and adaptable of the big cats. Its range includes much of sub-Saharan Africa and Asia and small populations also occur in the Middle East and south-eastern Europe (Hunter et al. 2003). It is endangered in parts of its range, particularly in the Middle East and northern Africa, where populations have become heavily fragmented and isolated and may have ceased to be viable (Uphyrkina et al. 2001). The leopard lives in a wide variety of different habitats, from semi desert areas to evergreen forests, and has even been found near major metropolitan areas (Bothma 1989). It can tolerate human activity and live in human-altered habitats and its elusive nature has enabled it to persist in places long devoid of other large predators (Hunter 1999). The persistence of the leopard is partly due to its opportunistic hunting behaviour and varied diet (Stuart and Stuart 1993, Bothma and Le Richie 1982). However, although fairly abundant in comparison to other large cat species, leopard numbers have been significantly reduced over the last hundred years due to increasing human population expansion, large scale habitat loss and fragmentation, hunting for trade, poaching, and retaliation over real or perceived human wildlife conflict (Uphyrkina et al. 2001).

1.1.1 Conservation status

As a result of their wide geographic range, leopards were assumed to warrant low conservation priority until recently. Indeed, from 1996 - 2008, at the species level, the leopard was classified on the IUCN Red List as "Least Concern" a categorisation for taxa that are widespread and abundant. The status of the leopard was reassessed in 2008 by the IUCN and re-classified as "Near Threatened." This reclassification was made due to the fact that although leopards are locally common in some areas of their range in Africa and tropical Asia, in larger areas population numbers are declining. For example, it is estimated that leopards have disappeared from at least 36.7% of their historical range in Africa (Ray et al. 2005). Within Africa, areas in which the leopard has experienced the most dramatic range loss include the Sahel belt, Nigeria and South Africa (Henschel et al. 2008). The category of "Near Threatened" indicates that the

species classified may soon qualify for the Red List status of “Vulnerable” if population numbers continue to decline (Henschel et al. 2008).

According to genetic analysis, nine subspecies of *Panthera pardus* are currently recognised (Uphyrkina et al. 2001). Of these subspecies, three are listed as “Critical” and are almost extinct – the Amur leopard (*pardus orientalis*), the Arabian leopard (*pardus nimr*) and the Javan leopard (*pardus melas*), and two are listed as “Endangered”– the Sri Lankan leopard (*pardus kotiya*) and the Persian leopard (*pardus saxicolor*). South Africa is home to the subspecies (*pardus pardus* Linnaeus, 1758), (Henschel et al. 2008). The next section will focus on the conservation status of the leopard in South Africa.

1.1.2 The Leopard in South Africa

There are currently very few accurate data on leopard numbers in South Africa and population density estimates only exist for a few protected areas (Hunter 1999). This is due to the fact that the leopard is elusive, solitary and largely nocturnal which makes obtaining empirical data difficult (Hunter et al. 2003). The national government also has little capacity to fund field research into wildlife and thus the national population status of the leopard is unknown. Despite the lack of data on leopard numbers in South Africa, it is considered to be widespread and abundant by the South African wildlife authorities. The South African leopard population was regionally assessed as being “Rare” in the National Red Data Book in 1986 and reclassified as “Least Concern” in the National Red Data Book of the Mammals of South Africa (Friedmann and Daly 2004). A taxon is given the status of “Least Concern” if it is considered to be widespread and abundant (Daly et al. 2005).

The leopard is threatened by a number of different factors in South Africa. These include habitat loss and fragmentation caused by human expansion and loss of prey species. The leopard is also heavily persecuted as a real or perceived livestock killer and is subject to legal and illegal off take for trophy hunting purposes (Henschel et al. 2008).

1.1.3 Trophy hunting and international trade in leopards

The African leopard is one of the most sought after game trophies and is legally hunted by foreign hunters in South Africa (Balme et al. 2010). In order to regulate international hunting, leopards are listed on Appendix I of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). CITES is an international agreement between governments that came into force in July 1975 to ensure that trade in specimens of wild animals and plants does not threaten their survival. Appendix 1 includes all species that are threatened with extinction and are affected by live trade or trade in their body parts. Any international trade in specimens of species on Appendix 1 is subject to regulation via export and import permits in order to ensure that it does not endanger the survival of that species (von Wielligh 2005). Trade in leopard skins, trophies or body parts are currently permitted by 12 African countries (Balme et al.2010).

Under CITES, South Africa has an export quota of 150 leopards. This quota is used by hunters to export leopard trophies and skins hunted in South Africa back to their country of origin. This quota was increased in 2005 from 75 export permits and is allocated to provincial South African authorities who distribute the permits to hunting outfitters or landowners within their province. Very little scientific input goes into quota setting and quotas are currently based on a 1.5% off take of an estimated population density of leopards. This population estimate is not based on empirical data but on an over simplified modelling attempt undertaken by Martin and de Meulenaer (1988) that correlated leopard numbers with rainfall and omitted information on prey density or human related mortality (Balme et al. 2010). From this model the researchers predicted that Africa had a population of 700,000 leopards and South Africa supported a population of 23,472 individuals. Martin and De Meulenaer's (1988) survey of the Status of the Leopard in Sub-Saharan Africa was reviewed by specialists from the IUCN/SSC Cat Specialist Group and the density estimates created by the model were universally rejected by members and are now considered to be highly flawed (Jackson 1989). In addition to the lack of scientific input in quota setting, there are no rigorous data on the numbers or population trends of leopards anywhere they are hunted in South Africa and no regulatory framework exists for harvesting leopards established by assessment of the impact of hunting (Balme et al. 2010).

1.1.4 Other anthropogenic causes of leopard mortality

Legal trophy hunting only accounts for a small percentage of leopard off-take in South Africa, problem animal control and illegal hunting account for far higher levels of leopard mortality (Balme et al. 2010). Leopards are killed legally and illegally due to livestock predation. If livestock farmers perceive a leopard to be taking domestic animals, they are legally permitted to kill it once they have been given a destruction permit by the provincial wildlife authority (von Wielligh 2005). Destruction permits are regularly awarded on little evidence and numbers of leopards removed as damage causing animals generally exceed those hunted legally each year (Balme et al. 2010). In 2004, approximately 50 permits were issued in South Africa to hunt livestock-damaging leopards (Hunter 1999). Many more leopards are destroyed illegally as livestock killers but it is very difficult to estimate these numbers as they are not reported. In addition leopards are also illegally hunted as trophies outside the permit system. Hunting pressure on leopards in South Africa is therefore very high (Hunter 1999).

1.1.5 Leopard population density in South Africa

As previously stated, there is a lack of accurate data on leopard numbers in South Africa. After the over simplified population modelling attempt undertaken by Martin and de Meulenaer, a later attempt was made in 2005 by the Conservation Breeding Specialist Group (CBSG – IUCN/SSC) and the Endangered Wildlife Trust (Daly et al. 2005). A workshop was set up by these organisations to assess the national status of the leopard via Population and Habitat Viability Analysis (PHVA). This assessment was undertaken in response to South Africa doubling their CITES leopard export quota in 2004. Results of the modelling process suggested that most of the identified leopard sub-populations would continue to survive if legal hunting was increased (Daly et al. 2005). Workshop participants acknowledged that results obtained from the modelling process did not represent accurate scientific fact but gave a broad overview of leopard population status.

1.1.6 The Leopard in Limpopo Province

This study was undertaken in the Soutpansberg Mountains in Limpopo Province, South Africa. Limpopo accounts for a large percentage of trophy hunting in South Africa (63%) and receives a high quota of leopard hunting permits. From 2003 the province was given a quota of 35 permits. This was increased to 50 in 2006 and Limpopo now has the largest allocation of leopard hunting permits in the country (Balme et al. 2010). No accurate population data exist for leopard numbers in the province. It is vital to have accurate data on leopard population numbers and trends in order to inform conservation decisions and management plans such as trophy hunting (Norton 1986). Accurate information on population density of the leopard across its range in South Africa is needed to find out whether the leopard is as abundant as is widely thought by the South African wildlife authorities. As Limpopo Province accounts for a large percentage of hunting activity in South Africa and has the largest number of trophy hunting permits for leopards, research is required to accurately estimate leopard numbers and assess whether current off-take rates are sustainable.

1.1.7 Trophy hunting as a conservation tool

Conservationists argue that trophy hunting has the potential to be used as a conservation tool for commercially hunted carnivores such as leopards (Loveridge et al. 2007, Lindsey et al. 2007, Balme et al. 2010). Money gained by landowners or local communities from selling hunting permits could be used to compensate stock losses and offset the costs of conflict between humans and predators. This could be used to encourage the toleration of wider populations of leopards on private and communal land, prevent illegal poaching and provide an incentive to conserve wildlife habitats (Leader-Williams and Hutton 2005).

1.1.8 Alternative methods of leopard conservation

This thesis focuses on the use of trophy hunting as a conservation tool for leopards, however alternative land management options exist that can be utilised for leopard conservation. These include ecotourism on private or community land and the management of blocks of private farms as conservancies.

Ecotourism involves offering tourists wildlife viewing and photography tours in exchange for fees. As tourists mainly want to see iconic 'big five' species in South Africa, many of these species are either bought in or naturally occur on ecotourism properties in order to attract tourists. In the context of leopard conservation, ecotourism operators obtain money from tourists seeing live leopards on their land rather than killing them, and this provides them with an economic incentive to tolerate them on their land even if leopards kill other economically valuable animals. The positive attitudes of ecotourism operators towards leopards are shown in Chapter 5 which focuses on the ways in which different land use groups perceive and value the leopard.

Conservancy land management is another land use option which can be used as a conservation tool for leopards. Conservancies are formed when neighbouring farms remove their internal fences in order to form larger collaborative wildlife areas (Lindsey et al. 2009). Conservancies have been found to benefit wildlife in a number of ways. Firstly, larger areas of land enable the reintroduction of a wider range of indigenous animals that smaller, fenced areas cannot hold and this often results in a shift from intensive, low value land use practices such as cattle farming towards higher value land utilisation options like game ranching. Research has found that under these land-use conditions, ranchers show more tolerance towards predators and often actively reintroduce them (Lindsey et al. 2009, this study). Collaborative management agreements typical of conservancies also tend to be more closely aligned with conservation objectives than on single properties (Lindsey et al. 2009). Land use options on conservancy properties include low impact tourism, game hunting and recreational land use. The environmental impact of these land use options is lower than that of smaller properties as they are conducted over a wider area.

1.2. Interdisciplinarity

Many projects set up to conserve wildlife focus solely on the ecological side of the issue with no input from the social sciences regarding analysis of the human aspect of conservation (Treves et al. 2006). As the attitudes and actions of humans that live with carnivores ultimately determine the success of conservation interventions, it is crucial that the human dimension is recognised and incorporated into management plans (Sillero-Zubiri and Laurenson 2001).

Interdisciplinary research has become a popular concept in recent years in academic research (Karlqvist 1999). Addressing conservation issues that involve interactions between humans and wildlife requires an interdisciplinary approach that can lie beyond the scope of one discipline (solely natural sciences or social sciences). Interdisciplinary involves an understanding of different disciplinary perspectives and requires the integration of data and information with the experience and perspectives of different stakeholders (Marzano et al. 2006). Interdisciplinary programmes often combine the work of separate natural scientists and social scientists within one research programme and each brings different bodies of knowledge, methodologies, styles of learning and interpretation to that research.

This study represents the first attempt to use a single researcher to undertake interdisciplinary research that spans both wildlife and human ecology and includes methodologies from both disciplines. This research is therefore both exploratory and innovative. The use of knowledge and methodologies from both of these fields has allowed the formation of a more complete understanding of the conservation and management issues facing leopards in the Soutpansberg and the local communities that live in close proximity to them.

1.3 Study site

This study was conducted in the western part of the Soutpansberg mountain range, Limpopo Province, South Africa. The Soutpansberg mountains are the northernmost mountain range in South Africa and lie between 23° 05' S - 29° 17' E and 22° 25' S - 31° 20' E (Berger et al. 2003).

The topography of the Soutpansberg is characterised by deep valleys and high cliffs and has altitudes that range from 250m above sea level to 1748m at its highest mountain peak 'Letjume' on the western half of the mountain range. The substantial local variation in topography in the Soutpansberg interacts with the macroclimate to form a complex and heterogeneous web of microhabitats and microclimates that support highly diverse communities of flora and fauna (Berger et al. 2003).



Figure 1.1 Map of South Africa showing the geographical location of the Soutpansberg mountain range (red) and the Lajuma Environmental Research Centre (Willems 2007).

1.3.1. Field site

The field site covers an area of approximately 600km² in the western Soutpansberg mountains and within this area, the Lajuma Environmental Research Centre (4.3 km²) served as a base for the project. Due to its high biotic diversity, Lajuma was declared a Natural Heritage Site in 1997. It also forms part of the Thavha Ya Muno Private Nature Reserve (50km²) and the Soutpansberg Conservancy. In addition, Lajuma is part of a local leopard conservancy.

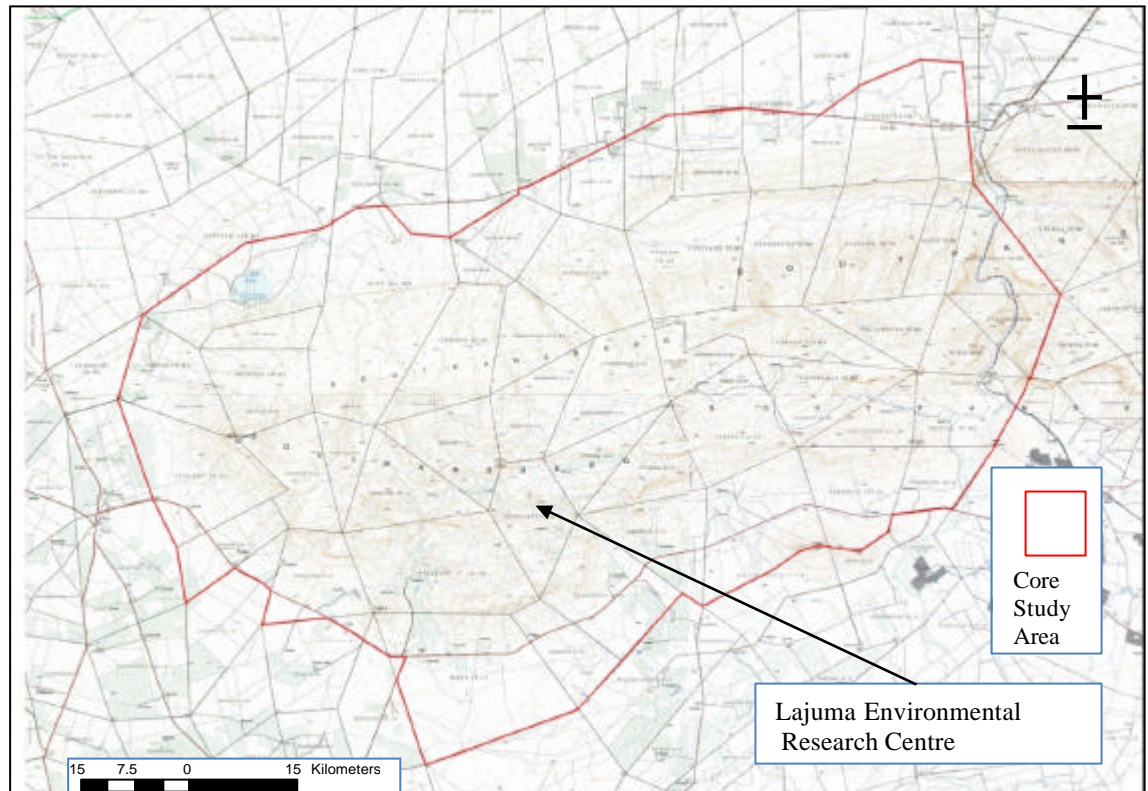


Figure 1.2 Study Area in the Soutpansberg Mountains

1.3.2 Topography, geology and soils

The Soutpansberg topographical zone covers an area of approximately 6800 km² in Limpopo Province, South Africa and runs in an east-westerly direction from the Blouberg Massif in the west to Punda Maria in Kruger National Park in the east. It covers a distance of approximately 250km from east to west and ranges from 15 - 60km in width from north to south (Berger et. al. 2003). Altitudinally, it ranges from 250 m above sea level to its highest western peak (1748 m) and has an east-west orientation with steep southern slopes and moderate northern slopes. Its highest ridges are found at the western extremity of the range (Mostert et al. 2008).

The Soutpansberg geological system is approximately 1,800 million years old and was formed by successive east-west faulting along the Tshamuvhudzi, Kranspoort, Nakab and Zoutpan strike-faults (Brandl 2003). This faulting was followed by a northwards tilting of the area, which created the Soutpansberg mountain range with its main south-facing cliff lines and northern side dipping at an incline of approximately 45° (Mostert

et al. 2008). The majority of rock formations in the Soutpansberg mountain range comprise of sandstone, quartz sandstone and pink, erosion resistant quartzite with a few igneous intrusions mainly composed of basalt and dolerite (Brandl 2003).

Major soil types in the area are shallow, acidic sandy soils derived from weathered sandstone and quartzite and rich clay soils derived from basalt and diabase dykes that are prone to erosion along the southern slope. Other soil types include fine-grained deep sands derived from the Aeolian Kalahari sands and peat soils that occur along the cooler high wetlands (Mostert et al. 2008).

1.3.3 Climate

The Soutpansberg mountain range has a significant influence on the climate of the area. Its topography gives rise to rainfall and wind patterns that create a diversity of micro-climates. There are three distinct climatic regions in the range. The climate is humid on the southern and eastern slopes of the higher peaks, sub humid in the south and semi-arid in the north of the mountain (Berger et al. 2003). Two main seasons exist in the Soutpansberg; the warm, wet season from December to February when temperatures range from 16 to 40°C and the cool and dry season from May to August when temperatures are cooler and range between 12 and 22°C (Kabanda 2003). The rainfall cycle in the Soutpansberg begins in October and runs until March with a peak from January to February. During the rainy season, rainfall levels vary greatly in different areas of the mountains due to the effects of orography on precipitation levels (Kabanda 2003). This local climatic variety gives rise to the high diversity of flora and fauna that is found in the Soutpansberg.

1.3.4 Flora and vegetation

The variation in the topography, geology, soil morphology and the highly localised microclimates of the mountain range have led to a diversity of vegetation types (Mostert et al. 2008). This diversity is related to the availability of moisture in the soil and the rate of environmental desiccation (Bond et al. 2003). The Soutpansberg has a high number of vascular plant taxa (2500-3000) and a large amount of plant species (approximately 3000) representing 1066 different genera and 240 families (Hahn 1997).

Five main vegetation types have been identified in the Soutpansberg (Mostert et al. 2008). These are:

1. The Soutpansberg Arid Northern Bushveld major vegetation type made up of open woodland with a sparse field layer which is confined to the northern ridges of the Soutpansberg Mountains.
2. The Soutpansberg Moist Mountain Thickets major vegetation type which is a mixture of plant communities and is characterised by closed thickets that show no separation between tree and shrub layers.
3. The Soutpansberg Leached Sandveld major vegetation type which is confined to the warmer northern slopes and arid southern slopes along the most northern ridges of the mountain range. These plant communities occur in dry areas of the mountains and are composed of a relatively homogenous group of woody and grass species.
4. The Soutpansberg Cool Mistbelt major vegetation type which is found 1200 m + above sea level and is confined to the mistbelt region of the mountain range. This vegetation type is diverse and includes peatlands, low open grasslands and small islands of thickets or bush clumps.
5. The Soutpansberg Forest major vegetation type which consists of evergreen high forests and deciduous shrub forest and is confined to the slopes of the most southern ridges of the mountain.

1.3.5 Fauna

The micro-habitats of the Soutpansberg mountain range are home to highly diverse animal communities. Thirty six percent of all known reptile species, 56% of bird species and 60% of all mammal species found in South Africa have been recorded here (Berger et al. 2003). 145 species of mammals occur in the Soutpansberg and the area is especially rich in bat, carnivore and hoofed mammals (Gaigher and Stuart 2003).

Despite the high faunal diversity of the Soutpansberg, uncontrolled colonial hunting during the 19th century and the destruction of habitat from farming practices has led to the decline and extinction of numerous animals (Mackenzie 1988). Of the twenty seven large herbivore species that used to live in the Soutpansberg mountain range, twelve are now extinct, among them the African elephant (*Loxodonta africana*) and the black rhino (*Dicero bicornis*) (Hahn 2006). In addition, cheetahs (*Acinonyx jubatus*) are no longer found on the mountain plateau and lions (*Panthera leo*) only remain in the far eastern part of the Soutpansberg (Gaigher and Stuart 2003). The only large carnivore species that remain in the mountain range are leopards, brown hyaenas (*Hyaena brunnea*) and spotted hyaenas (*Crocuta crocuta*) (Gaigher and Stuart 2003). Leopards therefore have fewer carnivore competitors here than in other parts of South Africa where the full complement of African carnivores still exist.

The leopard is well known for its opportunistic hunting behaviour and varied diet (Stuart and Stuart 1993, Bothma and Le Richie 1982). It is partly this flexibility in eating habits that have enabled it to survive in areas where other large carnivores have disappeared (Stuart and Stuart 1993). Several studies on the diets of leopards in the Soutpansberg have been conducted showing that leopards prey upon a high number of species (Nemangaya 2002, Schwarz 2003, Stuart and Stuart 1993). Prey animals present include four of the five primate species found in the Soutpansberg - the chacma baboon (*Papio cynocephalus ursinus*), Sykes's monkey (*Cercopithecus mitis albogularis*), the vervet monkey (*Cercopithecus aethiops*) and the thick tailed bush baby (*Otolemur crassicaudatus*).

Carnivore prey species present include African civet (*Civettictis civetta*), common genet (*Genetta genetta*), aardwolf (*Proteles cristatus*), caracal (*Felis caracal*) and water mongoose (*Atilax paludinosus*). Other carnivores that are also found in the Soutpansberg include African wildcat (*Felis silvestris*), serval (*Leptailurus serval*), honey badger (*Mellivora capensis*), Cape or African clawless otter (*Aonyx capensis*) and several mongoose species – the dwarf (*Helogale parvula*), slender (*Galerella sanguinea*) and banded mongoose (*Mungos mungo*).

Two species of hyrax are also found in the rocky areas of the Soutpansberg - the rock hyrax (*Procavia capensis*) and the yellow-spotted hyrax (*Heterohyrax brucei*) and are

both known to be highly favoured prey items (Nemangaya 2002, Stuart and Stuart 1993). Members of the order Rodentia present in the Soutpansberg that leopards take as prey include South African porcupine (*Hystrix africaeaustralis*), cane-rat (*Thryonomyidae*) and various species of the Muridae. Other prey species found in the area include the aardvark (*Orycteropus afer*), bush pig (*Potamochoerus larvatus*), scrub hare (*Lepus saxatilis*) Jameson's red rock rabbit (*Pronolagus randensis*), ground pangolin (*Smutsia temminckii*) and crested guinea fowl (*Guttera pucherani*).

Twenty five species of the order Artiodactyla also inhabit the Soutpansberg mountain range and many of these species are also preyed upon by leopards (Gaigher and Stuart 2003). These include bushbuck (*Tragelaphus scriptus*), mountain reedbuck (*Redunca fulvorufula*), southern reedbuck (*Redunca arundinum*), klipspringer (*Oreotragus oreotragus*), Sharpe's Grysbok (*Raphicerus sharpei*), red duiker (*Cephalopus natalensis*), common duiker (*Silvicapra grimmia*), impala (*Aepycerus melampus*), kudu (*Tragelaphus strepsicerus*), eland (*Taurotragus oryx*), hartebeest (*Alcelaphus buselaphus*), wildebeest (*Connochaetes taurinus*) and warthog (*Phacochoerus aethiopicus*). Other bovid and equid prey species present have recently been reintroduced by the game farming industry after being eliminated by overhunting. These include plains zebra (*Equus quagga*), sable antelope (*Hippotragus niger*), roan antelope (*Hippotragus equines*), buffalo (*Syncerus caffer*), nyala (*Tragelaphus angasii*) and waterbuck (*Kobus ellipsiprymnus*). In addition, several domestic livestock species such as cattle, donkeys, goats and sheep are found on communal and private farmlands.

1.3.6 The Soutpansberg landowning community

The Soutpansberg Mountains are located in Makhado Local Municipality in Vhembe District, Limpopo Province. Makhado Municipality covers an area of 16,000 km² and has a population of 458,000 inhabitants (Makhado Municipality Integrated Development Plan, 2005/2006). The majority of this population are black Africans living in rural areas with only 5% of the population of Makhado located in the urban centre (Vhembe District Municipality 2007).

The population is ethnically and culturally mixed and comprises black Africans, Afrikaners, South Africans of British descent and a small number of racially mixed

people. Languages spoken in Makhado are principally Venda and Shangaan (Tsonga), with Afrikaans, English and Pedi (Northern Sotho) spoken by smaller groups (Lahiff et al. 2006). Although the exact figures for the ethnic composition of Makhado Municipality are not available, Table 1 provides a breakdown of the ethnic composition of the whole of Vhembe District in 2007.

Table 1: Ethnic Composition of Vhembe District 2007 (taken from Provide 2009)

Ethnic Group	African	Coloured	White	Total
Population	1,196,677	406	15,736	1,212,819

Makhado Municipality is made up of two elements, the developed, commercial economy of the town of Makhado which was formerly the whites-only town of Louis Trichardt and surrounding commercial farms on one side of the town, and on the other side the small-scale agriculture of surrounding villages and townships. Most rural people live in these latter areas, which are lacking in infrastructure and services and previously formed part of the ethnically-based Venda ‘homelands’ (Lahiff et al. 2006). The Venda ‘homelands’ were set up during the Apartheid era by the then minority white rulers to facilitate the territorial separation of people along ‘racial lines’ (Lahiff 2006). The Soutpansberg Mountains lie on the opposite side of Makhado town from the old Venda ‘homelands’ and are therefore part of the more developed, commercial side of Makhado.

1.3.7 Land use

Land in the Soutpansberg and surrounding area is made up of a patchwork of community, game and cattle farms, ecotourism and conservation areas. In recent years the majority of cattle farms in the Soutpansberg area have been converted into game farms for hunting or eco-tourism purposes (Weisser et al. 2003). These commercial game farms are used to farm game species for the trophy hunting or ecotourism industry.

Within the study site, twenty three properties were identified and are owned by twenty different landowners or land owning communities. Of these properties, five are commercial cattle farms, five are used for game hunting, three are left fallow, another three belong to landowners that are involved in alternative income generation, a further two are part of a local conservancy, two are used for ecotourism purposes and two belong to local communities – one to a Venda communal farming community and the other to the Buys people.

1.4 Study Aims

The leopard is heavily hunted across South Africa both legally and illegally. Few data exist, on population numbers and thus current hunting pressure may be unsustainable. Wildlife management authorities recently increased legal hunting of leopards without information on leopard population density to support this decision. Many leopards are killed as livestock predators and are viewed by landowners as a drain on economic resources. However, trophy hunting may be used as a tool to conserve leopards if local communities profit from it and off-take numbers are sustainable and based on empirical data from population studies.

This study combines camera trapping and GPS telemetry of leopards with a detailed study of local perceptions of leopards to obtain information on leopard population density and dynamics and human-wildlife conflict in the area. This has been done in order to investigate the effectiveness and sustainability of trophy hunting as a conservation tool for leopards in the Soutpansberg Mountains. This research will be used to help mitigate human-wildlife conflict, improve the economic benefits of trophy hunting and inform sustainable management decisions for leopards.

1.4.1 Study Aims and questions:

- 1) To determine the population density and dynamics of the leopard in the Soutpansberg Mountains, a multi-use landscape site in South Africa.
- 2) To assess local attitudes to leopards, human-wildlife conflict and leopard conservation and examine the factors that shape these attitudes.
- 3) To discover the real versus perceived levels of human-wildlife conflict between landowners and leopards in the Soutpansberg.
- 4) To examine the potential of trophy hunting as a conservation tool for leopards in the Soutpansberg:
 - What are local evaluations of the current trophy hunting system?

- Is the current level of leopard trophy hunting sustainable?
- Does trophy hunting work as a conservation tool by providing an economic incentive to tolerate leopard populations on private and community land?

1.4.2 Thesis structure

Following this introduction, Chapter 2 examines the population density estimates obtained for leopards on two sites in the Soutpansberg via capture-recapture camera trapping. Chapter 3 investigates the home range and dispersal patterns GPS collared leopards and examines the existence of source and sink dynamics acting on the leopard population in the study site. Chapter 4 examines the data obtained on the spectrum of prey species taken by leopards in the Soutpansberg via scat analysis and combines these data with accounts of livestock predation events in order to examine differences between real and perceived leopard predation. Chapter 5 examines the perceptions and attitudes of landowners and farmers in the Soutpansberg Mountains towards leopards, leopard conservation and human-wildlife conflict and explores the way in which their associations with leopards vary according to membership of different social groups and land use categories. Chapter 6 investigates landowner attitudes towards trophy hunting of leopards and analyses local evaluations of the current trophy hunting system. Chapter 7 examines factors that can affect the sustainability of trophy hunting harvests and investigates whether the current legal and illegal leopard off-take in the Soutpansberg is sustainable via population viability analysis. Finally, Chapter 8 examines whether trophy hunting works as a conservation tool for leopards in the Soutpansberg by providing economic incentives to reduce illegal hunting. It also provides management recommendations to improve the sustainability and economic benefits of trophy hunting and explores the experience of undertaking interdisciplinary work using a single researcher.

2: Leopard population density and dynamics in the western Soutpansberg Mountains

2.1 Aims

Two camera trapping surveys were conducted in order to obtain accurate population density estimates for leopards via capture-recapture and spatially explicit capture-recapture camera trapping and provide information for an assessment of hunting pressure on leopards in the Soutpansberg Mountains.

2.1.2 Introduction

The leopard is one of the most geographically widespread of the big cats, is found across Africa and tropical Asia and is locally common in some of these areas (Henschel et al. 2008, Hunter et al. 2003). Despite its wide range and ability to adapt to diverse habitats and prey resources, the leopard has experienced a dramatic range loss in parts of Africa such as the Sahel belt, Nigeria and South Africa (Henschel et al. 2008). Leopards are found in both protected areas and on private farms or communal land but very few population data exist outside protected areas where many individuals persist (Hunter 1999, Uphyrkina et al. 2001). It is vital for wildlife authorities to have critical baseline data such as population density figures in order to sustainably manage leopard populations (Karanth et al. 2004a, Wegge et. al. 2004). In addition, population census methods used need to be accurate, reliable, and easy to apply (Jackson et al. 2006).

Solitary felids like the leopard that are cryptic, cannot be visually counted under normal field conditions and have large home ranges, are traditionally difficult to monitor (Balme et al. 2009, Silver et. al. 2004). Until recently, researchers attempted to estimate population densities of large cats via methods such as track identification and radio-tracking (Edgaonka and Chellam 2002, Rabinowitz 1989, Smallwood and Fitzhugh 1995). These methods are unsuitable for accurately estimating population densities as they can produce under or over estimates of population numbers, do not use formal population sampling approaches and lack comparable estimates of variance (Karanth and Nichols 1998). Population sampling based on track identification for example is not suitable for use in areas with uneven or heterogeneous substrates as tracks can be

distorted and may not be possible to identify correctly (Balme et al. 2009, Karanth and Nichols 1998). Accurate track identification also involves considerable expertise and time input which is not always available (Balme et al. 2009, Karanth and Nichols 1998). The use of radio or satellite tracking is also limited for estimating population densities due to the small number of animals it is possible to collar and the subsequent lack of knowledge available about individuals in the population that remain uncollared (Karanth and Nichols 1998).

In the last few decades, a population sampling technique based on a statistically robust theoretical framework has been developed known as capture-recapture camera trapping. This technique allows researchers to accurately estimate population densities of large felids that can be individually recognised from their natural markings (Karanth and Nichols 1998, Karanth et al. 2004). Camera trapping was first successfully used to obtain population sizes of tigers in Nagarahole National Park in India by Karanth (1995) as an alternative to the track census method employed by the Indian Government for its annual tiger counts (Panwar 1979, Karanth 1995). Sampling procedures were later refined to obtain population density estimates for tigers in other protected areas in India (Karanth and Nichols 1998). Since the development of camera trapping, this methodology has been used extensively for obtaining data on the density of a wide range of felids such as tigers, leopards, jaguars, snow leopards and ocelots (Balme et al. 2009, Jackson et al. 2006, Karanth et al. 2004a, Kawanishi and Sunquist 2004, O'Brien et al. 2003, Silver et al. 2004, Silveira et al. 2003, Soisalo and Cavalcanti 2006, Trolle and Kery 2003, Wegge et al. 2004). The application of camera-trapping has now widened and it is also utilised as a method for estimating the presence and absence of species in an area, for examining species richness, diversity and activity patterns (Azlan and Sharma 2006, Dillon and Kelly 2007, Kauffman et al. 2007, Tobler et al. 2008). Camera tapping methods have also now been developed that enable the estimation of animal densities using camera traps without the need for individual recognition of animals (Rowcliffe et al. 2008).

Camera trapping is an effective methodology for accurately estimating leopard population density (Balme et al. 2009, Henschel and Ray 2003). In their study of leopard ecology in KwaZulu Natal on a private reserve in South Africa, Balme et al. (2009) evaluated the efficiency of camera trapping and track counts as population estimators for leopards. The researchers tested the ability of these methodologies to determine leopard population densities for a known density of radio-collared individuals (7.33/100 km²). The density estimate derived from camera trapping showed greater accuracy (6.97/100 km²) than the one obtained via track counts (6.45 /100 km²) and these results established camera trapping to be a more accurate methodology for estimating the abundance and density of leopards. The researchers also argued that camera trapping involves less financial input and time costs than radio-telemetry or track surveys.

2.2 Leopard population densities

Very little accurate data on leopard population densities exists apart from for a few protected areas (Hunter et al. 2003). Before the advent of camera trapping, many researchers relied on data from radio-telemetry studies, observation of habituated leopards, track counts and spoor tracking to estimate leopard numbers (Bailey 1993, Balakrishnan and Easa 1986, Bothma and le Riche 1984, Cavallo 1993, Edgaonka and Chellam 2002, Hamilton 1976, Jenny 1996, Mitzutani and Jewell 1999, Norton and Henley 1987, Rabinowitz 1989, Santiapillai et al. 1982, Schaller 1972, Seymour 2004, Smith 1978 and Stander 1997).

Table 2.1 shows a number of leopard population densities calculated using different methodologies. A great deal of variation exists in leopard densities across their range. Very low population numbers of leopards have been found in arid areas such as the Kalahari Gemsbok National Park, South Africa where spoor tracking estimated leopards densities at 0.625 per 100km² (Bothma and le Riche 1984) and Kaudom Game Reserve in Namibia where spoor tracking and radio-tracking found leopards exist in low numbers of 1.5 animals per 100km² (Standar et al. 1997). On the other end of the population scale, extremely high leopard densities have been estimated for areas such as the prey rich, riparian forest zone of Kruger National Park, South Africa which Bailey (1993) calculated supported 30.3 leopards per 100 km². The highest recorded leopard

density estimate in Table 2.1 originates from Londolozi Private Game Reserve in Sabi Sands, South Africa, where rangers used observation of habituated leopards to estimate a density of 52 individuals per 100km² (Seymour 2004). This wide variation in leopard density is due to factors such as differences in levels of prey availability, persecution levels, habitat availability and hunting cover (Karanth et al. 2004a). Another source of variation is the use of different methodologies to calculate leopard population density. The density of 52 individuals per 100km² for example was obtained solely by observation of habituated leopards and also includes young animals (Seymour 2004). Juveniles are often not included in radio-telemetry and camera trapping studies as young leopards have low capture probabilities (Karanth 1995). The inclusion of juveniles in this density estimate makes comparisons of leopard densities between this study and those using other methodologies impossible.

Some published data exist on leopard population densities estimated via capture-recapture based camera trapping (Balme et al. 2009, Chauhan et al. 2005, Harihar et al. 2009, Henschel 2008, Wang and Macdonald 2009). These range from very low densities in the high mountainous habitat of Jigme Singye Wangchuck National Park, Bhutan (1.04 per 100km²) to the high densities discovered in Sariska Tiger Reserve, India (23.5 per 100km²) (Chauhan et al. 2005, Wang and Macdonald 2009). In Africa, estimates exist for leopard densities calculated by camera trapping at Phinda Private Reserve in Kwa-Zulu Natal (7.33 per 100 km²) and the lowland rainforest areas of Lopé and Ivindo National Parks, Gabon (2.7-12.1 per 100km²) (Balme et al. 2009, Henschel 2008). Further studies are needed to accurately calculate population densities of leopards in non protected areas. It is vital to have accurate data on leopard population numbers and trends in order to inform conservation decisions and management plans such as trophy hunting (Norton 1986).

Table 2.1. Comparative leopard densities in Asia and Africa

Study	Location	Habitat	Density (no per 100km²)	Method
Bailey 1993	Kruger NP	Riparian forest zone Good leopard habitat and lots leopard prey	30.3	Radio-telemetry
Bailey 1993	Kruger NP		3.5	Radio-telemetry
Balakrishnan and Easa 1986	Parambikulam Wildlife Sanctuary, Kerala, India	Wet evergreen forest, tropical semi-evergreen forest, secondary moist mixed deciduous forest	2.13	Pug marks
Balme et al. 2009	Phinda Private Game reserve, Kwa-Zulu Natal, South Africa	Natal lowveld bushveld, coastal, bushveld-grassland	7.33	Camera trapping
Bothma and le Riche 1984	Kalahari Gemsbok NP, South Africa	Semi-arid, dunes and sandveld savannah with dry riverbeds	0.625	spoor tracking
Cavallo 1993	Serona, Serengeti NP	Woodland	4.7	Radio-telemetry
Chauhan et al. 2005	Sariska Tiger Reserve, India	Dry forests	23.5	Camera trapping
Edgaonka and Chellam 2002	Sanjay Gandhi NP, Maharashtra, India	Moist deciduous forest	38.8	Pugmarks

Study	Location	Habitat	Density (no per 100km²)	Method
Hamilton 1976	Tsavo National Park		7.7	Radio-telemetry
Harihar et al. 2009	Chilla Forest Range, Rajaji National Park, India		14.99	Camera trapping
Henschel 2008	Lopé and Ivindo National Parks, Gabon	Primary/secondary lowland rainforest	2.7-12.1	Camera trapping
Jenny 1996	Tai NP, Ivory Coast	Rainforest	8.7	Radio-telemetry
Mitzutani and Jewell 1998	Ranches, Laikipia District, Kenya	Ranchland	12.5	Radio-telemetry
Norton and Henley 1987	Cedarberg Wilderness Area	Fynbos Mountains	7.5	Radio-telemetry
Rabinowitz 1989	Huai Kha Kaeng Wildlife Sanctuary, Thailand	Tropical forest	4	Radio-telemetry
Santiapillai et al. 1982	Ruhuna NP, Sri Lanka		17.86	Observations/road transects
Schaller 1972	Serona, Serengetti NP	Woodland	4.12/3.5	Radio-telemetry

Study	Location	Habitat	Density (no per 100km²)	Method
Seymour 2004	Londolozi, Sabi Sands, South Africa		52 (including young and transients)	Observation of habituated leopards
Smith 1978	Rhodes Matopos National Park, Rhodesia	open woodland and grassland	17	spoor tracking
Stander et al. 1997	Namibia, Kaudom Game Reserve, Bushmanland Communal Area	Semi-arid savannah	1.5	Radio-tracking combined with spoor tracking
Wang and Macdonald 2009	Jigme Singye Wangchuck National Park, Bhutan	High and rugged mountains, wet sub tropical to permanent alpine pastures and glaciers	1.04	Camera trapping

2.2.1 Leopard density and trophy hunting in South Africa

As discussed in Chapter 1, despite the lack of information on leopard population numbers, leopards are legally hunted in South Africa as trophy animals. Legal international trade is regulated by the Convention for the International Trade of Endangered Species (CITES) which set quotas for the export of leopard trophies. Although commercial trade in leopards is not allowed, under current CITES regulations, 12 African nations are permitted to export a total of 2,648 leopard skins obtained via trophy hunting, and of these countries South Africa has an export quota of 150 skins per year (Balme et al. 2010).

Very little scientific input goes into quota setting for trophy hunting permits and quotas are currently based on a 1.5% off take of an estimated population density of leopards. In addition to the lack of scientific input in quota setting, there are no rigorous data on leopard numbers or population trends anywhere they are hunted in South Africa (Balme et al. 2010). In order to ensure that harvests of leopards are sustainable, hunting quotas need to be founded on accurate assessments of population density to ensure that the leopard is not being over-harvested (Spong et al. 2000). If this is not done, unsustainable commercial harvests may cause declines in populations already endangered by illegal persecution and habitat loss.

2.2.2 Population modelling

The model on which the South African CITES quota is founded on was created by Martin and de Meulenaer (1988). As outlined in Chapter 1, Martin and de Meulenaer (1988) based this model on a correlation between rainfall and leopard numbers for savannah habitats in East Africa and used it to predict numbers of leopards across their entire sub-Saharan African range. The model was later reviewed by scientists from the IUCN/SSC Cat Specialist Group who universally rejected the leopard density estimates produced and argued that the methodology used was highly flawed (Jackson 1989).

The main problem with the model was that Martin and De Meulenaer applied their density/rainfall regression to all areas in Africa, assuming every habitat was suitable for leopards irrespective of prey densities or human persecution. Because of this oversight

they predicted population densities where leopards no longer survived or gave a greatly exaggerated population density estimate for mountainous or forest areas (Jackson 1989). Recent studies have shown that carnivore densities are positively correlated with prey densities meaning that lack of prey is an important limiting factor and affects carnivore distribution and abundance (Karanth et al. 2004b). The absence of prey density as a variable in the model was therefore a serious omission. The model greatly overestimated leopard numbers in places such as the mountainous areas of the Cape Province where leopards live in much lower densities than savannah habitats due to persecution and low prey density (Norton 1990). Martin and de Meulenaer (1988) used the study of Coe et al. (1976) as support for their relationship between leopard density and rainfall. Coe et al. (1976) established a correlation between herbivore biomass and rainfall using large herbivore numbers from savannah habitats. However, in the mountainous areas of the Cape, research has shown that small mammals such as rock hyrax and rodents are the main source of leopard prey (Norton 1989). It was therefore inappropriate to predict leopard numbers in the Cape using this correlation. Despite the fact that the population figures derived from Martin and de Meulenaer's study have been universally rejected as exaggerated and inaccurate, the model is still used to set CITES trophy hunting quotas (Balme et al. 2010).

A later attempt to estimate leopard numbers in South Africa via population modelling was made by Daly et al. (2005). In 2005, a multi-stakeholder workshop including researchers, NGOs, the South African Department of Environmental Affairs and Tourism (DEAT) and the Professional Hunters' Association of South Africa (PHASA) was convened in South Africa to assess the national status of the leopard. This assessment was undertaken in response to South Africa doubling their CITES leopard export quota from 75 to 150 permits in 2004 (Daly et al. 2005).

From the workshop, participants concluded that the South African leopard meta-population consisted of 10 sub-populations and a population viability analysis model was developed to examine the effect of different off-take levels and management scenarios on the survival of individual sub-populations over time. Population data input into the model were based on the informed opinion of workshop members regarding habitat, prey availability, terrain, density and conflict with humans (K Traylor-Holzer pers.comm). Results of the modelling process based on this data suggested that most of

the leopard sub-populations would continue to survive if legal hunting was increased with the exception of the Eastern Cape and the Wild Coast. It was agreed that the results of the model did not constitute an accurate picture of the current status of the leopard but represented best guess estimates that could be used to provide a general overview of the species' situation and persistence. However, despite the fact that workshop participants acknowledged that results obtained from the model did represent accurate scientific data, members of the professional hunting industry in South Africa have since used the findings as support for the continued sustainability of leopard trophy hunting (I. Gaigher pers.comm).

2.2.3 Trophy hunting quotas in Limpopo Province

Limpopo accounts for a large percentage of trophy hunting in South Africa (63%) and receives a high quota of leopard hunting permits. From 2003 the province was allocated a quota of 35 permits. This was increased to 50 in 2006 and Limpopo now has the largest allocation of permits for all the provinces (Burgener et al. 2005). No accurate population data exists for leopard numbers in Limpopo although they are considered to be widespread. Decisions on trophy hunting need to be based on sound and accurate population density data to ensure that the species is not being locally overharvested.

The next section will examine current issues in the design and analysis of camera trapping studies, will then go on to analyse the data obtained from the camera trapping surveys within the context of the wider literature and finally investigate its implications for trophy hunting.

2.3 Methodology

Camera trapping was used in this study in order to obtain a population density estimate for leopards in the Soutpansberg. This methodology is an effective survey technique that has been used to estimate leopard population densities across a number of sites in Asia and Africa (Balme et al. 2009a, Edgaonka and Chellam 2002, Harihar et al. 2009, Henschel 2008, Henschel and Ray 2003 and Wang and Macdonald 2009). Camera trapping is a population sampling technique based on a statistically robust theoretical framework known as capture-recapture. It was developed in the last few decades and allows researchers to accurately estimate population densities of large felids that can be individually recognised from their natural markings (Karanth and Nichols 1998, Karanth et. al. 2004).

To establish the population density of leopards at a site, leopards are photographed by cameras that are triggered remotely when the leopard moves through an infrared beam. Each leopard is then identified by its unique coat pattern. To estimate the population size of leopards on the project site from camera trapping results, the data is analysed using the programme CAPTURE (Otis et al 1978). CAPTURE utilises a number of models to provide the best estimate of population size. The programme also tests for violations of mark-recapture hypothesis. Leopard density in the sampling area is estimated as CAPTURE provides an estimate of the sampling area. Confidence intervals around those estimates are also provided.

For camera trapping to produce the most robust estimates of leopard populations, it is important to have a high enough capture rate of leopards to be able to apply capture-recapture statistics (Henschel and Ray 2003). The camera trap survey area needs to be large enough to contain at least parts of the home ranges of several individuals. The accuracy of the density estimate increases with population size, as the larger the area, the smaller the 'edge effect' (the chance of overestimating density because some animals counted along the edge of the survey area are only partial residents).

Two camera trapping surveys were conducted to determine leopard densities on the project site. The first survey ran from March to May 2008 and the second survey from

August to October 2008. For these surveys 30 Cuddeback® Digital Scouting Cameras were used (Expert model, Non Typical Inc, USA).

It was initially planned that cameras would be set out in a grid formation with a spacing of 2 km apart creating blocks of 4 km² into which each camera pair would be set. This method of camera placement is adopted by a number of researchers in order to ensure unbiased and even coverage of the survey area with traps (Johnson et al. 2006). The grid was drawn using a jpeg map of the study site which was uploaded into the program Mapsource (Garmin International, Inc., USA). Within this grid, random GPS points were generated using ArcMap 9.2 (ESRI) for each 4km² block and cameras were to be placed within 100m of this point on the nearest road or trail.

When potential camera trapping sites were investigated it was found that grid based randomised placement of cameras was not possible in the area due to the topography of the Soutpansberg Mountains. This form of placement meant that randomised points were frequently sited on cliff sides or other inaccessible areas and it was not possible to place cameras at these points. In order to maximise capture probability of leopards it was decided that cameras would be placed on roads and trails known to be frequented by leopards without using a grid formation. This method of camera placement is recommended by Karanth and Nichols (2002). Scat and track surveys were undertaken across the study site in order to identify these roads and trails. See Figure 2.3 for camera trap locations for both surveys.

To ensure there were no holes in the study design that may contain the entire home range of an individual which would remain unphotographed thus affecting the resulting density estimate, cameras were positioned closely enough in order to cover the territory of individuals with the smallest territory size (adult females) (Karanth and Nichols 2002). The smallest home range record for an adult female is 9 km² in a prey rich forest in Thailand (Grassman 1999). To ensure even camera coverage of an area of approximately 9 km², at least 2-3 camera trap pairs were positioned with a distance of about 2 km in between traps (Henschel and Ray 2003, Karanth and Nichols 2002). Distances between cameras was measured using an Etrex Garmin global positioning system (GPS), (Garmin International, Inc., USA).

Cameras were set in pairs to ensure that photographs of both sides of the animal could be taken and were placed at a height of 40cm either side of roads and trails. This corresponds to the approximate shoulder height of an adult leopard (Henschel and Ray 2003). Metal roofs were also designed and fixed above the cameras in order to protect them from adverse weather conditions. Cameras were set at approximately 6 metres apart to ensure that the entire flank of each leopard would be captured. Figure 2.4 provides an example of a camera trap set up.



Figure 2.2: Camera trap set up

The cameras were set to run continuously and were programmed to the smallest delay available for the models (1 minute in between photographs). In order to meet the assumption of population closure (the sampling period is short enough such that no births, deaths, or emigration/immigration incidents occur) each survey lasted for 9 weeks (Karanth and Nichols 2002). It was important to ensure the surveys ran for this length of time as failure to satisfy the hypothesis of a closed population during mark-recapture studies can lead to overestimates in population size (Karanth and Nichols

2002). To prevent battery failure cameras were checked initially after one week and every two weeks after this. Frequent camera checking also made it possible to examine the effect of camera positioning on photograph quality and make any changes to the camera set up as required. Four cameras malfunctioned during the survey and these were replaced immediately with older models of Cuddeback Experts available on the site.

Before the data collection period, pilot studies were conducted for both camera trapping surveys. Pilots provided data on the best places to site cameras, which individuals used a particular area and helped to ensure each camera was optimally set up to maximise capture probabilities of individuals. The examination of pilot photographs showed if cameras were placed too close to the road (therefore not displaying a whole leopard), were placed in a sloping area that leopards tended to run down (leading to blurred photos without identifiable spots) or were sited in an area that was too open and leopards would not be guaranteed to pass. In response to this information cameras were re-positioned to obtain maximum capture probability. Photographs from camera traps were downloaded from memory cards onto a laptop and once images were saved, the date, time and location of each photograph was noted. Individual leopards were identified via their unique spot patterns and a capture history was created for each animal.

2.3.1 Camera trapping study design and analysis

As the usage of camera trapping has increased over the past decade, an awareness among researchers has arisen that camera trap surveys need to be designed and analysed in a systematic way to produce comparable species density estimates (Dillon and Kelly 2007, 2008, Karanth et al. 2004a, Rowcliffe and Carbone 2008, Balme et. al. 2009). Recent research has shown that if camera trapping studies are not designed systematically and analysed consistently this can lead to overestimations of species density. The use of inflated density estimates is of concern as it can create underestimates of the threat faced by a species thus affecting conservation plans (Dillon and Kelly 2007). Study design and analytical factors that have been found to influence density estimates in camera trapping studies include trap spacing, the use of small

survey areas and lack of information on home range sizes of target species (Dillon and Kelly 2007, 2008, Maffei and Noss 2008, Soisalo and Cavalcanti 2006).

A particular problem in the analysis of capture-recapture camera trapping studies is the conversion of the population size estimate produced by the programme CAPTURE, used to analyse the data, into a density estimate (Balme et al 2009, Dillon and Kelly 2008, Soisalo and Cavalcanti 2006). In order to do this a buffer zone needs to be added to the area enclosed by the outer camera traps to estimate the total area surveyed. This is added as individuals photographed in the survey also come from the area outside the perimeter of these camera traps. The buffer zone is added to account for the additional area from which leopards are trapped (Karanth and Nichols 1998, Otis et al. 1978, White et al. 1982). Traditionally buffer zones have been estimated by calculating the $\frac{1}{2}$ mean maximum distance moved ($\frac{1}{2}$ MMDM) by animals between each camera station at which they have been captured (Wilson and Anderson 1985, Karanth and Nichols 1998). This measurement is used as a proxy for home range radius (Wilson and Anderson 1985, Karanth and Nichols 2002). However, some researchers have found that adding a boundary strip calculated using $\frac{1}{2}$ MMDM overestimates population densities of species as it underestimates distances moved by individuals (Dillon and Kelly 2008, Soisalo and Cavalcanti 2006).

Soisalo and Cavalcanti (2006) in their study of jaguar population density in the Brazilian Pantanal calculated buffer zones using both the $\frac{1}{2}$ MMDM method and estimated an alternate buffer strip using home range data obtained via GPS telemetry. A comparison of jaguar density estimates using the two methods found that densities calculated using $\frac{1}{2}$ MMDM may have been overestimated by as much as 74% in comparison to using home range data (Soisalo and Cavalcanti 2006). Dillon and Kelly (2008) also used radio-telemetry to obtain data on ocelot home range size and compared the radius of the average ocelot home range with the standard camera trapping buffer ($\frac{1}{2}$ MMDM). Density estimates based on the average home range radius were much lower than those determined using the $\frac{1}{2}$ MMDM buffer and were similar to those determined using twice the standard camera trapping buffer to estimate density, the full MMDM.

Another factor which has been found to increase density estimates is the inclusion of animals in the calculation of $\frac{1}{2}$ MMDM that have moved zero distance between

captures (Dillon and Kelly 2007). Some camera trapping surveys include zero-distance moved animals in their analyses of density (Kelly 2008, Silver et al. 2004) whereas others do not (Trolle and Kery 2003, Maffei and Noss 2008). Dillon and Kelly (2007) discovered that the inclusion of zero-distance moved animals almost doubled one of their estimates of ocelot density in Belize from a camera trapping survey from 19.3 to 38.5 ocelots per 100km². When zero distance moved animals were excluded, the resulting buffer zones increased with the sampling area and the accompanying densities reduced in size. The results from these studies show that agreement needs to be reached regarding the design and analysis of camera trapping surveys in order to produce comparable species density estimates.

2.4 Study design

Two camera trapping surveys were conducted to determine leopard densities on the project site. Details of camera trapping methodology and study design can be found in Chapter 2. Both surveys lasted for 9 weeks. The first survey ran from March to May 2008 and the second survey from August to October 2008. Fig 3.1 shows the locations of the camera trapping surveys in the Soutpansberg mountains. The first survey was located on the southern side of the mountains and covered one hunting farm, an ecotourism property, a cattle farm, two conservancy properties and one communal farm area. The second survey was conducted in an area that was partially located on the northern side of the Soutpansberg. The survey area did not include any cattle farms or communal land but covered one commercial hunting farm, an ecotourism property and three properties on conservancy land.

2.4.1 Analysis

Identification of leopards

The sex and age class of each photographed leopard was established via the presence of external genitalia, relative body size and musculature and where visible, tooth colour and wear. Individual leopards were identified via their unique spot patterns and compared to photographs with already identified animals. Images that were blurred or did not show enough of an individual were not used for identification purposes. Photographs obtained from the camera traps were of very high quality (3 mega pixels) therefore it was possible to unambiguously identify almost all individuals captured.



Figure 2.3 Example of individually identifiable leopards based on their characteristic spot patterns.

A) & B) show the same male leopard, and C) shows a second male.

A) First male



B) Same male



C) Second male

2.4.2 Statistical methods

After all leopards were identified, a capture history was created for each individual. The capture history consists of a standard ‘X-matrix format’ in which each leopard has an ID and the number of trapping nights is shown as occasions along the top of the matrix (Otis et al. 1978). If an animal is photographed on an occasion it is marked as a ‘1’ in the matrix and if it has not been captured during a trapping occasion this is shown as a ‘0.’ Each camera trapping night was used as a trapping occasion as there were enough cameras to cover the entire trapping area. The mountainous topography of the site made it impractical to move cameras to new positions during the surveys, therefore cameras remained the same positions throughout each survey period.

Capture histories were analysed via the computer programme CAPTURE (Otis et. al. 1978, White et. al. 1982, Rexstad and Burnham 1991) which is available as free software from <http://www.mbr-pwrc.usgs.gov/software.html>. CAPTURE uses different models to generate population abundance estimates based on the number of individual animals captured and the frequency of their recaptures. The population estimators used by CAPTURE differ in the assumed sources of variation that may affect capture probability such as the behavioural response of individuals to camera trapping (e.g. trap avoidance), time specific variation (e.g. weekly weather changes) and heterogeneity between individuals due to differences in sex, age or territorial status (Karanth et al.

2004a). These models include the null model (M_0) which assumes there is no variation between leopards in capture probabilities nor is there an effect of the time of capture or behavioural response to trapping (Karanth 1995). Other models available are M_h which permits different capture probabilities for each individual but assumes that probabilities of capture are not affected by heterogeneity or time, M_t which accounts for the effect of time on capture probability but does not include variation between individuals on a trapping occasion and M_b which models for the effect of behavioural response to being captured for the first time but does not include temporal or individual variation in capture probability (Karanth and Nichols 1998).

Estimators that include the effects of two sources of variance on the probability of capture are also available. These include M_{bh} (behavioural response and heterogeneity), M_{th} (time and heterogeneity), M_{tb} (time and behavioural effects) and M_{tbh} which includes the effects of heterogeneity, behavioural response and time. CAPTURE has a model selection function that analyses the capture data, compares the different population estimation models, scores potential models between 0.0 and 1.0, and then chooses the model with the highest score that best fits the data. These population models were developed for closed populations and assume that there are no changes within the sampled population during the survey period such as births, deaths, immigration or emigration from the study area (Karanth and Nichols 1998). CAPTURE also computes a closure test statistic to test the closed population assumption for the data and estimates the capture probabilities and population size of the species in question (Karanth and Nichols 1998, Karanth et al. 2004).

In order to obtain the density (D) of animals in the study area the population estimation provided by CAPTURE is divided by the size of the area surveyed. This population density can be defined as $D = N/A$, in which N is the population size computed by CAPTURE and A is the area covered by the camera trapping survey (the area in which the population is found) (Karanth and Nichols 1998). As previously discussed, the total area from which leopards are trapped is not equal to the convex polygon that connects the outer most camera trapping stations. Leopards caught by the cameras also come from the area outside the perimeter of these camera traps and therefore it is necessary to add a buffer zone to account for the additional area from which leopards are trapped (Karanth and Nichols 1998, Otis et al. 1978, White et al. 1982).

As previous research has found that using different methods to calculate the buffer zone affects the size of the population density estimate obtained via camera trapping, four different methods were used to estimate the buffer area. Firstly, it was calculated using the standard method of $\frac{1}{2}$ mean maximum distance moved by animals between each camera station (Wilson and Anderson 1985, Karanth and Nichols 1998). As the inclusion of individuals that have been repeatedly recaptured at the same camera station (zero-distance moved animals) in the calculation of $\frac{1}{2}$ MMDM has been found to increase density estimates obtained via camera trapping (Dillon and Kelly 2007), buffer zones were calculated with both the inclusion of zero-distance moved animals and without them to examine the resulting effect on the density estimate produced.

A further calculation of the effective trapping area was made using home range data obtained from GPS telemetry. Only two animals were collared during this study, an adult female and a sub-adult male. As movement data from the sub-adult male suggested that he was dispersing during the study, only home range data for the adult female was used for the buffer calculation. Ideally the home ranges of a much larger number of animals should be averaged and then used to calculate buffer values; however, this was not possible due to low live capturing and collaring success. The minimum convex polygon method was used for home range calculation using 95% of the female's GPS location data (95% MCP) and it was estimated using the Home Range extension for ArcView 3.2 (ESRI Inc, 1992-2002). The resulting home range was then used to calculate the buffer width applying the equation $A = \pi r^2$ where A is the estimated area of a circle equivalent to the leopard home range and r is radius of that circle which can then be used as the buffer width (Balme et al. 2009, Soisalo and Cavalcanti 2006).

A final calculation of the buffer zone was made using the full mean maximum distance moved (MMDM) by animals between each station at which they have been captured for comparison with other buffer zone measurements and density estimates.

2.5 Results

2.5.1 Photographic captures of leopards

Camera trapping methodology used within a capture-recapture framework was found to be successful for obtaining population density estimates for leopards. Both surveys ran for 9 weeks in order to meet the assumption of demographic closure. The first one was conducted from 20th March to 21st May 2008 and the second survey from 1st August to 2nd October 2008. The first survey took place just before the beginning of the dry season which runs from May to August whilst the second camera trapping survey was conducted at the end of the dry season. Initially to reduce variation caused by seasonality it was planned that both surveys would be undertaken in the dry season but due to time constraints caused by moving camera traps from one side of the mountain to the other it was not possible to conduct the surveys exactly within the same season. Table 3.2 shows the sampling effort for both surveys.

Table 2.2 Camera trap sampling effort for two camera trap surveys in the western Soutpansberg Mountains

Survey	Dates (2008)	Days	Camera stations	Trapping Nights
Camera Trap Survey One	20th March - 21st May	63	13	819
Camera Trap Survey Two	1st Aug - 2nd Oct	63	14	882

During the first survey, 134 photographs (68 left flanks and 66 right flanks) of 14 individual leopards (9 females and 5 males) were obtained over 819 trap nights. During the second survey 46 photographs (26 left flanks and 20 right flanks) of 10 individuals (5 females and 5 males) were obtained over a period of 882 trap nights. The capture histories of individually identified leopards in both camera trapping surveys are given in Appendix 3. These data were used to calculate capture frequencies. The number of

captures and recaptures in the first survey ranged from 1 to 19 and in the second survey captures and recaptures varied from 1 to 6. Two leopards were only captured once in both surveys. Only adult leopard individuals were used to calculate leopard densities in this study as cubs of solitary felids (age <1 year) have been found to have low capture probabilities (Karanth 1995).

2.5.2 Model selection, tests for population closure and capture probabilities

The jackknife estimator M_h (Burham and Overton 1978, Otis et al. 1978) had the highest selection criterion for both surveys (1.0), therefore population estimates using this model have been used. This estimator has been found to perform well when used in other capture-recapture studies examining population densities of large felids (Karanth and Nichols 1998, Karanth et al. 2004a).

Closure test results for the first camera trapping survey indicated that the assumption of closure was not violated ($z = -1.024$, $P = 0.15297$) but results for the second survey indicate lack of closure ($z = -1.742$, $P = 0.04073$) as shown in Table 3.3. Under M_h , the average capture probability for leopards in the first survey was $P = 0.0685$ and for the second survey it was $P = 0.0410$.

Table 2.3 Leopard captures and recaptures by survey, with estimated capture probability per sampling occasion (p) using the jackknife model of variable probability of capture (M_h), and the results of the closure test.

Camera trap survey	Total captures / recaptures	Individuals	Individuals recaptured	Male	Female	p	Closure Test	
							z	p
Camera Trap Survey One	69	14	12	5	8	0.0685	-1.024	0.15297
Camera Trap Survey Two	31	10	8	5	5	0.0410	-1.742	0.04073

2.5.3 Estimates of leopard population size, effectively sampled area and leopard densities

Using the model M_h , the estimated leopard population size in the first survey was 16 with a standard error of 2.1511 (95% CI 15 to 25). For the second survey the estimated leopard population size was 12 with a standard error of 2.1228 (95% CI 11 to 20). Leopard densities using the standard $\frac{1}{2}$ MMDM camera trapping buffer were 42 / 100km² at survey site one and 30.3 / 100km² at the second survey site as shown in Table 3.4.

Table 2.4. CAPTURE results for two camera trap survey sites showing population size using model M_h , the boundary strip width as determined by the $\frac{1}{2}$ mean maximum distance moved (1/2 MMDM), and the resulting leopard population density

Survey	Population size +/- SE	95% CI	$\frac{1}{2}$ MMDM	Effectively sampled area	Density
First	16 se 2.1511	15 to 25	0.52 km	38.2 km ²	42 / 100km ²
Second	12 se 2.1228	11 to 20	0.47 km	39.6 km ²	30.3 / 100km ²

Leopard densities estimated using a measurement of $\frac{1}{2}$ MMDM camera trapping buffer that did not include zero distance moved animals were 28.3 / 100km² at survey site one and 13.7 / 100km² at the second survey site as shown in Table 3.5.

Table 2.5 CAPTURE leopard density results for two camera trap survey sites estimated via a measurement of the 1/2 MMDM that did not include zero-distance moved animals

Survey Number	$\frac{1}{2}$ MMDM (no zero MMDM)	Effectively sampled area (no zero MMDM)	Density (no zero MMDM)
First	1.24 km	56.5 km ²	28.3 / 100km ²
Second	2.06 km	87.9 km ²	13.7 / 100km ²

Leopard densities estimated using a measurement of the full MMDM camera trapping buffer were 31.1 / 100km² at survey site one and 23.1 / 100km² at the second survey site as shown in Table 3.6.

Table 2.6 CAPTURE results for two camera trap survey sites showing leopard densities estimated via the use of full mean maximum distance moved (MMDM)

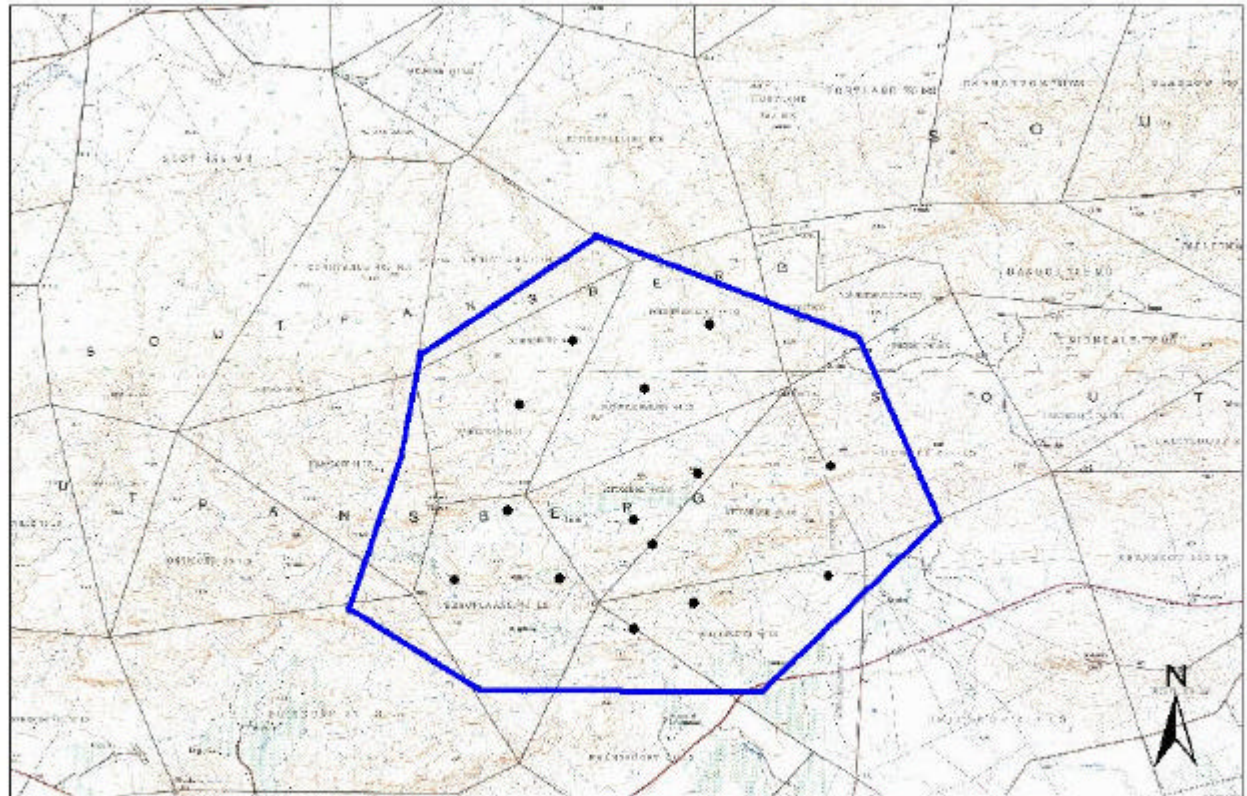
Survey Number	MMDM	Effectively sampled area	Density
First	1.05 km	51.4 km ²	31.1 / 100km ²
Second	0.93 km	52 km ²	23.1 / 100km ²

The home range estimate derived from GPS telemetry data used for the alternate calculation of the effective trapping area was 14.51 km² and the resultant buffer width calculated from the home range estimate was 2.15km². Using this calculation, leopard density for the first survey was estimated to be 19 / 100km² at survey site one and 13.2 / 100km² at the second survey site.

Table 2.7. CAPTURE results for two camera trap survey sites showing leopard densities estimated using a buffer width calculated from GPS telemetry data

Survey Number	Buffer width	Effectively sampled area	Density
First	2.15 km ²	84.3 km ²	19 / 100km ²
Second	2.15 km ²	91.1 km ²	13.2 / 100km ²

Figures 3.2 and 3.3 show the camera trap locations for both surveys and a measurement of the effective sampled area using GPS telemetry data for the calculation of the buffer zones.



- Camera locations
- Effective sampled area Camera trap Survey One

0 0.5 1 2 3 4
kilometers

Figure 2.4 Map of camera survey one showing camera trap locations and the effective sampled area calculated via GPS telemetry data

2.5.4 Spatially explicit capture-recapture

As discussed earlier in this chapter, a problem exists in the analysis of capture-recapture camera trapping studies in the conversion of the population size estimate produced by CAPTURE into a density estimate (Balme et al 2009, Dillon and Kelly 2008, Soisalo and Cavalcanti 2006). The conversion of population size requires an estimate of the total area surveyed to produce a density estimate (Karanth and Nichols 1998). As the total area from which leopards are trapped is not equal to the polygon that connects the outer most camera trapping stations and individuals also come from the area outside the this polygon, a buffer zone is added in order to account for the additional area from which leopards are trapped (Karanth and Nichols 1998, Otis et al. 1978, White et al. 1982).

Buffer zones have been traditionally estimated by calculating the $\frac{1}{2}$ mean maximum distance moved ($\frac{1}{2}$ MMDM) by animals between each camera station at which they have been captured as a proxy for home range radius (Wilson and Anderson 1985, Karanth and Nichols 1998, 2002). However, some researchers have found that adding a boundary strip calculated using $\frac{1}{2}$ MMDM overestimates population densities of species as it underestimates distances moved by individuals (Dillon and Kelly 2008, Soisalo and Cavalcanti 2006). Overestimates of density can have important conservation and management consequences. In harvested animals such as the leopard, higher density estimates could translate into higher, potentially unsustainable harvest levels. Negative consequences may include local extirpation because inflated estimates could lead to management decisions that place endangered populations at greater risk (Obbard 2010).

The technique of using $\frac{1}{2}$ MMDM is ad hoc, does not have a specific justification based on formal statistical models or an understanding of animal movements and is viewed as a weakness in the use of this methodology (Karanth et al. 2006, Royale et al. 2009, Royle and Young 2008, Soisalo and Cavalcanti 2006).

To minimise the risk of inflated density estimates Spatially Explicit Capture Recapture (SECR) was also used to analyse camera trapping data. SECR is a newly developed analytical method used to estimate species population density. It provides a more accurate measurement for the effective survey area than capture-recapture analysis as it

uses the locations where each animal is detected to fit a spatial model of the detection process (Borchers & Efford 2008, Efford, Borchers & Byrom 2009, Efford, Dawson & Borchers 2009). This analytical method obtains estimates of population density unbiased by edge effects, incomplete detection and heterogeneous capture probabilities.

Spatially Explicit Capture Recapture was conducted via the use of SPACECAP Version 1.0.1 (Singh et al. 2010). SPACECAP is a software package for estimating animal densities that uses closed model capture-recapture sampling based on photographic captures.

SPACECAP works within the program R (R Development Core Team, www.r-project.org). It implements spatially explicit capture-recapture models developed in a recent paper by Royle et al. (2009). Spatially explicit capture-recapture directly estimates animal density by using information on capture histories in combination with spatial locations of captures under a unified Bayesian modelling framework. These models are hierarchical models composed of two components: a point process model describing the distribution of individuals in space (or their home range centres) and a model describing the observation of individuals in traps (Royle et al. 2009).

2.5.5 Methodology

Three input files are required to run the SECR analysis in SPACECAP - the animal capture details file which contains details on animal ID number, trap location number and sampling occasion number; the trap deployment details file (trap spatial location, deployment activity, sampling occasion number) and the state-space details file which describes the potential animal home range centre details. These files were produced in Microsoft EXCEL, saved in an ASCII comma separated format (.csv), and input into SPACECAP. A copy of the animal capture details file can be found in Appendix 4a.

The Trap deployment details file contains data on trap deployment (expressed in X and Y-coordinates), deployment activity and sampling occasion number. This file provides SPACECAP with the dates when each camera trap location was active and operational during the survey to account for trapping effort (Singh et al. 2010). Trap deployment data are stored in a two dimensional matrix of camera trap locations and sampling

occasions in a binary, 0/1 format, where 0 indicates that a particular camera trap station was not operational on a specific sampling occasion, and 1 indicates that it was operational. This file is not included in the appendices as all camera trap sites were operational during sampling occasions therefore each sampling occasion was shown as a 1.

The state-space details file describes the potential animal home range centre details in terms of their spatial location and habitat suitability for these home range centres. In SPACECAP analyses, the surveyed area containing the camera trap array combined with an extended area surrounding it, known as the "state-space" of the underlying point process, which is represented by a large number of equally spaced points in the form of a fine mesh (Singh et al. 2010). These points represent all the possible potential activity or home range centres of all the animals in the population being surveyed.

Home range centres were created using GIS software package ArcView 9.3 (ESRI). Firstly a polygon was formed by connecting the outermost camera traps in survey one. A buffer of 10km was then added to the polygon. The width of the buffer was large enough to ensure that no individual animal outside of the buffered area had any probability of being captured by camera traps during the survey. A fine grid of points which represent leopard home range centres was then generated for this extended area. In order to examine whether the potential home range centres were in areas of suitable or unsuitable habitat (e.g. in the middle of a main road or village), they were plotted on a base map of the area. The state-space details file contains the X and Y coordinates of all the potential activity centres and habitat suitability indicators for each centre. If the potential activity centre lies within suitable species habitat this was indicated with a 1 or with a 0 if it was in unsuitable habitat. A copy of this file is shown in Appendix 4b.

Table 2.8 shows the input values required by SPACECAP in order to run a SECR analysis.

Table 2.8. SECR model input values

Model inputs	Explanation	Value
Area of potential home-range centres	Pixel size area of a potential home-range centre is dictated by species biology (e.g. a few hundred meters for leopards)	0.4 km ²
No of iterations	This defines the number of MCMC iterations for the analysis	50,000
Burn-in	This defines the number of initial values to discard during the MCMC analysis	1000
Thinning	Only iteration numbers defined by the thinning rate are stored during the analysis	1- no thinning
Data augmentation	This is a computational device that enables a convenient Bayesian analysis of capture-recapture models where N is unknown. N = population of individuals having their activity centres on the prescribed state-space.	140 (10 times individuals captured in the study)
Model chosen	Spatial Capture-Recapture which runs a spatially explicit capture-recapture analysis	N/A

2.5.6 Results

Figure 2.7 shows the layout of potential home range centres of leopards in the first camera trapping survey, the camera trap polygon of the outer perimeter of cameras and the buffer zone added to the polygon to exclude leopards from outside the survey area in the density calculation.

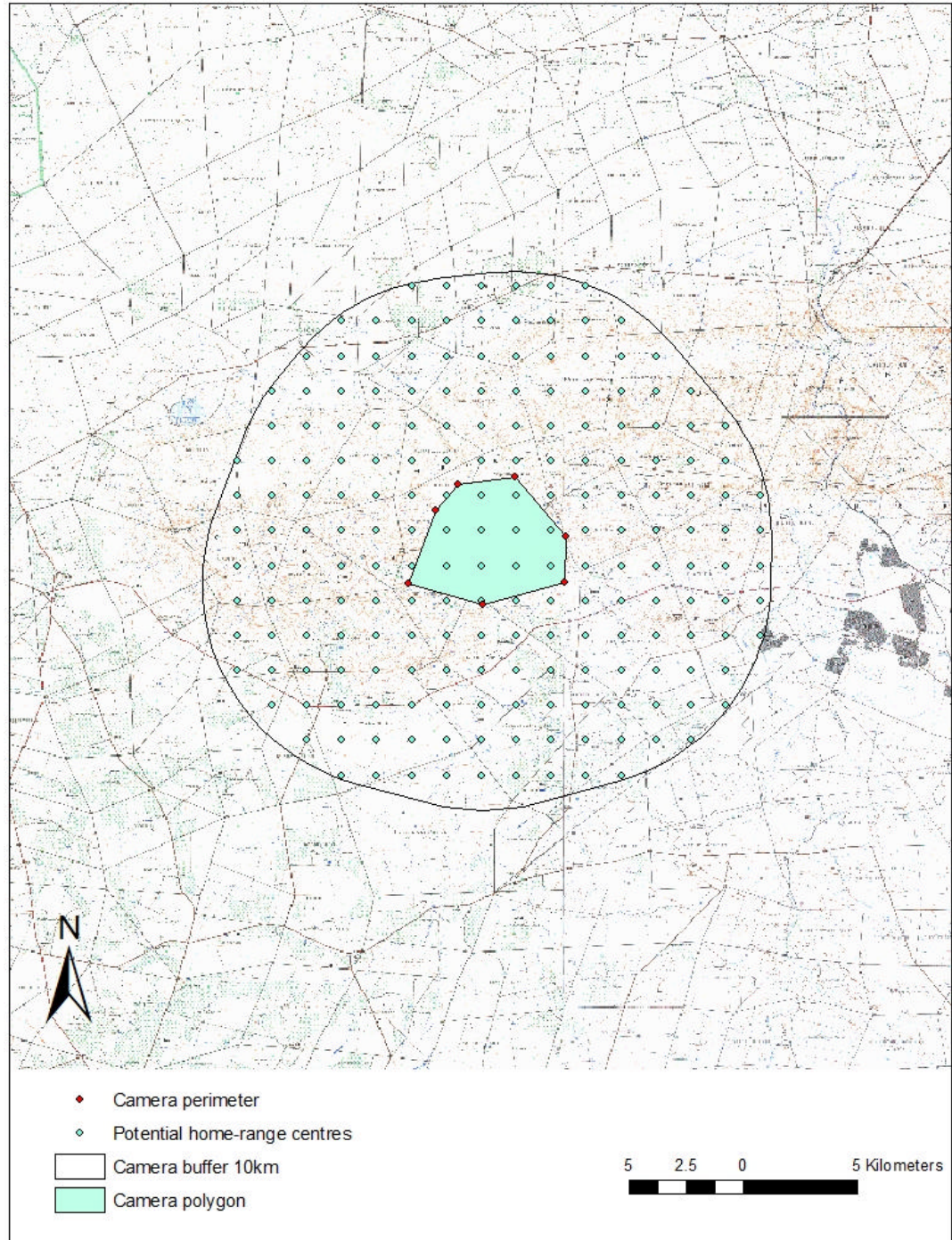


Figure 2.6 Survey One: Map of potential home range centres, with camera trap polygon and buffer zone

As shown in Table 2.9, spatially explicit capture recapture provided a mean density estimate of 19.97 leopards per 100 km² in the survey area with a standard deviation of 0.547. The lower 95% HPD Level was estimated at 19.774 leopards per 100km² and the higher 95% HPD Level at 21.1864 leopards per 100km².

Table 2.9. SECR results for camera trap survey one

	Posterior Mean	Posterior SD	95% Lower HPD Level	95% Upper HPD Level
Sigma	1.6E+08	8.05E+08	1.00E-04	618847162.6
lam0	0.0062	0.001	0.0045	0.0084
Beta	1.0693	1.8071	-3.2337	4.2727
Psi	0.0972	0.024	0.0524	0.1449
Nsuper	14.1382	0.3873	14	15
Density	19.9692	0.547	19.774	21.1864

2.6 Discussion

2.6.1. Capture-recapture camera trapping analysis

2.6.1.1 Population closure

The CAPTURE test in this study indicated population closure for the first camera trapping survey but not for the second one. Both surveys ran for 9 weeks in order to meet the assumption of demographic closure where the population remains constant in size and composition throughout the period of investigation (Karanth and Nichols 2002).

One reason for the lack of population closure in the second survey may be that although the requirements of demographic closure were met, the assumption of geographic closure may have been violated (Wegge et al. 2004). Violation of geographic closure occurs when individuals move onto and off a sample area during a survey period (Gardner et al 2009). This can affect the ability to interpret estimates of population size derived from closed population capture-recapture models (Royle et al. 2009).

Another reason for lack of closure in the second survey may be the effect of trap shyness. Trap shyness can occur when individuals become frightened by the night-time

flash on the camera traps and then avoid the same camera stations therefore reducing the probability of being recaptured at that site (Wegge et al. 2004). Results from camera trapping studies of tigers in India (Karanth and Nichols 2002) and Nepal (Wegge et al. 2004) have shown evidence of trap shyness. Karanth and Nichols (2002) found that of 26 individual tigers captured during 10 nights of trapping, 23 were captured in the first five nights and only 16 during the following 5 nights. Total captures were 33 and 25 in the first and second 5-day period, indicating that trap shyness may have been involved (Wegge et al. 2004).

Wegge et al. (2004) in their study of tiger density in Nepal found that capture rates decreased by more than 50% after the first 5 days of trapping and statistical analyses confirmed a behavioural response among individuals in nearly all of the tests.

The capture history of leopards in the second camera trap survey in this study indicates that some individuals did become trap-shy. Of the 10 individuals captured over 63 nights of trapping, 8 were captured during the first half of the survey, whereas only 2 new animals were photographed in the second half. Also of the 31 total captures made, 20 took place in the first section of the survey and 11 during the second half. These data suggest that camera trap shyness may have occurred thus accounting for the violation of population closure detected by CAPTURE.

Trap shyness can be reduced by camouflaging camera trap stations or by the use of infrared cameras in order to avoid the use of flash. Both of these precautions will be taken when conducting any camera trap surveys in the future. However, as only the first camera trap survey showed closure only the density estimate for this survey will be used for further analysis in the rest of this thesis.

2.6.1.2 Leopard population density

Densities obtained via capture-recapture based camera trapping were greatly affected by the size of the buffer zone used in calculating the effective sampled area as has been found in other studies (Balme et al. 2009, Dillon and Kelly 2007, 2008, Soisalo and Cavalcanti 2006). Leopard population densities at the first camera trapping survey site ranged from 19 – 42 leopards per 100km² and from 13.2 – 30.3 per 100km² at the

second survey site depending on the method used to calculate the buffer zone. Densities were highest using the standard $\frac{1}{2}$ MMDM camera trapping buffer zone (42 per 100 km² and 30.3 per 100km²) and lowest when replacing this buffer zone with one calculated from GPS home range data (19 per 100km² and 13.2 per 100km²).

As previously discussed, researchers have found that the use of the standard $\frac{1}{2}$ MMDM camera trapping buffer zone or the inclusion of zero distance moved animals in density calculations can cause a substantial overestimation of population densities (Dillon and Kelly 2007, 2008, Soisalo and Cavalcanti 2006). Densities obtained in this study using the standard $\frac{1}{2}$ MMDM camera trapping buffer zone, the full MMDM or including zero distance moved animals appear to be extremely high and may represent over-estimates for the Soutpansberg leopard population. If these data were correct that would indicate that leopard densities are almost as high as or higher than those found the riparian areas of Kruger National Park which Bailey (1993) estimated at 30.3 per 100 km². It is much more likely that the density estimate derived using GPS telemetry data (19 per 100km² and 13.2 per 100km²) gives the most accurate representation of leopard population numbers and these figures will be used to represent leopard densities in the Soutpansberg for the remaining chapters. Balme et al. (2009) concluded that small sample size can reduce accuracy when using home ranges to estimate buffer zone sizes. To ensure greater accuracy in the estimation of leopard densities, home range estimates of a number of males and females would need to be averaged and the mean could then be used to more accurately measure the buffer zone and effective sampled area. As male leopards normally exhibit larger home ranges than females, the inclusion of this data would further reduce the population density estimate.

Even with the use of the density estimate derived using GPS telemetry data, these results suggest that there is a high population of leopards in the Soutpansberg mountains. These data are most closely comparable to densities of leopards estimated via camera trapping from the dry forests of Sariska Tiger Reserve, India (23.5 leopards per 100km²) and Chilla Forest Range, Rajaji National Park, India (14.99 per 100km²) (Chauhan et al. 2005, Harihar et al. 2009). The extrapolation of the population density results obtained from this study cannot be undertaken to other areas in Limpopo Province however, as they only relate to the unique mosaic habitat, climatic conditions and prey densities found in the Soutpansberg Mountains. This area also has little human

settlement and low agricultural activity unlike other parts of the province. Leopards may therefore experience much lower levels of persecution in the mountain and have access to larger areas of suitable habitat and more abundant prey; therefore densities found here would be higher than those beneath the mountains.

2.6.2. Spatially Explicit Capture-Recapture camera trapping analysis

The density estimate produced via SECR of 19.97 leopards per 100 km² is under half of that calculated using the traditional technique of estimating the buffer zone via ½ MMDM (42 per 100km²). It is also considerably lower than the density estimate produced using full MMDM (30.1 per 100km²). However, the density estimate produced using the buffer width calculated from GPS telemetry data (19 per 100km²) is very close to that obtained via SECR analysis. This suggests that densities calculated using ½ MMDM may generate a large overestimation of leopard numbers and that a more accurate measure of density is produced using estimates of effective sampled area based on data from telemetry studies or one that use information on capture histories in combination with spatial locations of captures such as SECR.

It is vital that population densities of harvested species are not overestimated via inaccurate analytical methods as this could translate into potentially unsustainable harvest levels, thus leading to further population declines in species already at risk from high levels of legal and illegal hunting.

2.6.3 Implications for trophy hunting quotas in Limpopo Province

Wildlife authorities should not rely on guesswork or highly inaccurate estimates of leopard density to establish sustainable levels of harvests for a species already under threat from illegal hunting and habitat loss. Camera trapping is an accurate method of estimating leopard density and work undertaken by Balme et al. (2009a) has shown that this method is effective and low cost. Despite these findings it is still not used by wildlife authorities for setting leopard quotas (Balme et al. 2010). The Department of Environmental Affairs and Tourism in Limpopo Province needs to be strongly encouraged to utilise leopard population data obtained via camera trapping to set quotas for legal off-take.

2.6.4 Future work

Further work on leopard population density needs to be conducted in Limpopo Province. A comparative camera trapping survey should be undertaken in a study area more characteristic of land use in Limpopo with higher human population densities and higher leopard persecution levels. This research could be used to assess the status of the leopard in more representative areas of the province and obtain accurate population density data which can be used by wildlife managers in order to inform legal off take plans in areas with lower leopard densities.

3. Leopard home range, movements and population sources and sinks in the Soutpansberg Mountains

3.1 Aims

A home range study was conducted using GPS satellite telemetry to obtain information on leopard home range size and movements, factors contributing to leopard mortalities and to identify population sources and sinks in the Soutpansberg Mountains. GPS telemetry data were also used to provide information for the of calculation camera trapping survey areas.

3.2 Introduction

The home range of an individual can be defined as the area in which an animal travels in pursuit of its daily activities such as obtaining food, mating and caring for young (Burt 1943, Harris et al. 1990). This area does not include the entire range that an animal moves within its lifetime but is restricted to the vicinity in which it conducts these routine activities (Jewell 1966). Exploratory movements outside this area by individuals such as sub-adults are not included as part of an animal's normal home range (Burt 1943).

Obtaining information on home range size is highly important for conservation management purposes as it provides data on the spatial and habitat requirements of leopards and indicates how they utilize the landscape in which they live (Simcharoen et al. 2008). Information on leopard home ranges can also provide evidence on the spacing of individuals, their dispersal movements, mortality rates and landscape factors affecting mortality such as population sources and sinks (Harris et al. 1990, Hunter et al. 2003, Nilsen et al. 2008).

3.2.1 Leopard home ranges

In most solitary felids such as the leopard, the basic pattern of land occupancy is made up of the home ranges of resident males which overlap with those of two or three

resident females (Bailey 1993, Kitchener 1991). Male home ranges are usually larger than those of females and there is often little overlap between home ranges of the same sex (Bailey 1993, Schaller 1972). Within the ranges of resident animals transient individuals can also be found. These are either sub-adults that have not yet dispersed from their natal areas or young or old leopards that are passing through to find vacant home ranges (Bailey 1993).

Home range size is affected by a number of different behavioural and ecological factors. Adult female home ranges are determined by the abundance and distribution of food resources and the presence of denning sites for rearing young (Bailey 1993, Marker and Dickman 2005, Mizutani and Jewell 1998, Sunquist and Sunquist 1989). Male home range size is determined by the availability of reproductively active females and may be larger than females' ranges due to the need to maximise mating opportunities and have access to a number of females with which to mate (Bailey 1993, Marker and Dickman 2005, Mizutani and Jewell 1998). Male home ranges may also be larger than females' due to males' larger body size and accompanying increase in energy requirements (Carbone and Gittleman 2002). Other factors that may also affect home range size in solitary felids include the availability of hunting cover and inter and intra-specific competition (Gittleman and Harvey 1982).

Studies undertaken on leopard home ranges have shown that there is a great variation in home range size across different regions and habitats as shown in Table 4.1 (Bailey 1993, Bertram 1982, Bothma and Le Riche 1984, Bothma et al. 1997, Jenny 1996, Le Roux and Skinner 1989, Marker and Dickman 2005, Mizutani and Jewell 1998, Norton and Lawson 1985, Norton and Henley 1987, Stander et al. 1997). This emphasises the ecological flexibility of the species. Variation in home range size is mainly due to resource availability and differences in prey distribution and density caused by the diversity of climatic conditions and habitats in which leopards are found (Bailey 1993, Bothma et al. 1997, Gittleman and Harvey 1982, Odden and Wegge 2005, Schaller 1972). Previous research has provided evidence that leopards living in dry, prey poor areas with little habitat diversity exhibit much larger home ranges than those living in less arid habitats with higher prey densities (Bailey 1993, Bothma et al. 1997, Mizutani and Jewell 1998, Stander et al. 1997). Adult male leopards living in areas with low rainfall such as the semi-arid savannahs of the Kalahari Gemsbok National Park, South

Africa and Kaudom Game Reserve, Namibia have the largest recorded home ranges (Kalahari, 2182.4 km², Bothma et al. 1997; Namibia, 451.2 km², Stander et al. 1997), whereas leopards in more humid, prey rich areas such as Kruger National Park in South Africa and Loldiaga Hills Ranch, Kenya exhibit much smaller ranges (Kruger NP, 47.1 km², Bailey 1993; Kenya, 37.1 km², Mizutani and Jewell 1998).

Table 3.1 Average home range sizes of adult leopards in sub-Saharan Africa

Reference	Study Area	Habitat	Home range males (N)	Home range females (N)
Bailey 1993	Kruger NP, South Africa	Woodland savannah	47.1 km ² (5)	12.4 km ² (6)
Bertram 1982	Serengeti NP, Tanzania	Wooded grassland		15.9 km ² (1)
Bothma et al. 1997	Kalahari Gemsbok NP, South Africa	Semi-arid savannah	2182.4 km ² (3)	488.7 km ² (5)
Jenny 1996	Tai NP, West Africa	Tropical forest	86 km ² (1)	25.4 km ² (2)
Le Roux and Skinner 1989	Sabi-sands Game Reserve, South Africa	Woodland savannah		23 km ² (1)
Marker and Dickman 2005	North-central farmland, Namibia	Thornbush savannah	76. km ² (2)	14.8 km ² (4)
Mizutani and Jewell 1998	Loldiaga Hills Ranch, Kenya	Wooded grassland	37.1 km ² (2)	16.9 km ² (3)
Norton and Lawson 1985	Stellenbosch Mountains, South Africa	Fynbos mountains	388 km ² (1)	487 km ² (1)
Norton and Henley 1987	Cedarberg Wilderness Area, South Africa	Fynbos mountains	51 km ² (3)	
Stander et al. 1997	Kaudom Game Reserve, Namibia	Semi-arid savannah	451.2 km ² (6)	188.4 km ² (3)

Leopard home range sizes may also be affected by anthropogenic factors such as trophy hunting and persecution from farmers (Marker and Dickman 2005, Norton and Lawson 1985). In their study of leopard ecology in the Stellenbosch Mountains, South Africa, Norton and Lawson (1985) discovered that individuals tracked via radio-telemetry displayed very large home ranges (female - 451.2 km², male - 388 km²) in comparison with individuals from similar areas. The researchers concluded that this low population density may have been caused by a long history of persecution by farmers as well as a low density of available prey. Similar conclusions were made by researchers examining factors affecting spatial ecology in leopards on Namibian farmlands (Marker and Dickman 2005). Marker and Dickman (2005) found that leopards in their study site exhibited comparatively larger home ranges than leopards from other areas with similar levels of prey biomass and argued that this may be due to the high levels of persecution by local landowners in retaliation for livestock losses.

3.2.2 Dispersal of sub-adults

Dispersal is the movement of an individual from its natal area to an independent home range (Howard 1960, Hansson 1991). It is a demographic mechanism that takes place in order to promote gene flow and prevent inbreeding in populations and can aid in the recolonisation of vacant habitats and the recovery of sink populations (Stoner et al. 2008). Male leopards typically disperse from their natal areas once sexual maturity is reached whereas females favour philopatry and tend to remain closer to their mother's home range (Johnson 1986, Pusey and Packer 1987). Juvenile leopards generally reach nutritional independence from between 13-18 months but studies have found a great variation in dispersal age which may be related to factors such as the availability of resources, competition with resident animals and the existence of nearby vacant home ranges (Mizutani and Jewell 1998, Schaller 1972, Stander et al. 1997, Sunquist 1983).

3.2.3 Population sources and sinks

Source and sink dynamics can have serious impacts on the growth or decline in population numbers of a given species. They arise when there are differences in birth and death rates in areas within a landscape (Pulliam 1988). Sink habitats occur when local reproduction is insufficient to balance local mortality and source populations arise when reproduction in an area outweighs local mortality (Dias 1996). Populations may persist in sink areas via immigration from more productive source areas nearby as individuals disperse outwards from sources to find vacant home ranges in sink habitats (Pulliam 1988). Source-sink dynamics can be caused by differences in hunting pressure and human persecution within a landscape, creating 'attractive sink scenarios' where animals disperse into sink areas with suitable habitat but cannot detect the aspects of the habitat which make it a sink and therefore become subject to the increased local mortality acting within the sink (Delibes et al. 2001, Novaro et al. 2005). The persistence of a population on a regional scale depends on the proportion of sink habitats in relation to source areas (Novaro et al. 2005).

Research undertaken on carnivore populations subject to hunting off-take has shown that spatial differences in hunting pressure can produce sources and sinks (Novaro et al. 2005, Robinson et al. 2008). Novaro et al. (2005) examined the effects of patchily distributed hunting on the survival of culpeo foxes, (*Pseudalopex culpaeus*), in Argentine Patagonia. They discovered that the survival rate of juvenile culpeos was lower on sheep ranches than on cattle farms as culpeos experienced hunting for their fur and for sheep predation on the sheep ranches. The higher hunting pressure on sheep farms created sinks for culpeos but populations were maintained via dispersal of juveniles from cattle farms where no hunting occurred. Robinson et al. (2008) in their study of the dynamics of a hunted population of cougars, (*Puma concolor*), in Washington State, USA also found that uneven hunting pressure created a sink within their study site for source populations in the surrounding areas. Source-sink dynamics have important management implications for species subject to hunting off-take such as the leopard in South Africa. Both source and sink areas need to be identified within a landscape and reduced harvests may be required in source areas to compensate for losses due to immigration into sink areas (Novaro et al. 2005).

3.2.4 Leopard home ranges in the Soutpansberg

The landscape in the Soutpansberg is made up of a patchwork of game, cattle and communal farms that are utilised for hunting, farming, conservation and ecotourism purposes. Properties included in this study range in size from less than 1km² to 34 km² (I.Gaigher, pers.comm). Fencing exists between these properties but fences do not serve as barriers to leopards that are able to move freely from one farm to another. The home range of a single leopard in the Soutpansberg can therefore encompass a variety of properties with differing land uses and on some parts of its home range a leopard will be protected from persecution, whereas in other areas it may be hunted for trophies or killed for stock raiding. It is important to know home ranges sizes for leopards in the Soutpansberg in order for leopards to be managed sustainably within in this multi-use landscape.

No published information exists on the home range sizes of leopards in the Soutpansberg. One unpublished study (Stein 2005) estimated the home ranges of two adult male leopards via radio-telemetry as 45km². Data from radio-tracking fixes provided an initial estimate of 25km² using the minimum convex polygon method but this figure was increased by the researcher to 45km² to account for difficulties experienced tracking leopards in the mountains. No other home range information exists for leopards. GPS satellite telemetry was used in this study to provide a more accurate estimate of leopard home ranges in the mountainous area of the Soutpansberg as it enables the collection of location data from areas in which researchers are not able to go.

3.3 Measuring home ranges

One of the most common methods of home range estimation is radio-tracking. This technique involves determining the location of an animal through the use of radio signals which are transmitted from a radio-tracking device (Mech and Barber 2002). Radio-tracking has been used since its introduction in the 1960's to obtain data on the location, movement and behaviour of a species in order to estimate home range sizes and habitat use (Harris et al 1990). Very high frequency (VHF) radio-tracking is the

most traditional radio-tracking technique used. This method entails collaring an individual with a VHF transmitter and following it on foot or by air with a directional antennae and VHF receiver (Mech and Barber 2002).

Over the last 15 years, advances have been made in the fields of Geographical Information Systems (GIS) and Global Positioning Systems (GPS) which have led to the development of GPS satellite tracking as an alternative to VHF radio-tracking. GPS tracking consists of a GPS unit and a microprocessor which programmes the schedule of GPS activity (Hemson 2002). Once an animal is captured and sedated the unit is attached to an animal via a collar. When active, the GPS unit provides location data by receiving coded signals from at least 4 of a network of 24 GPS satellites. The signals contain details of the satellite position and the local time which is generated by 4 atomic clocks aboard each satellite. By comparing time signals the unit is able to calculate its position (Hemson 2002). GPS telemetry has a number of advantages over the use of VHF radio-tracking. Large amounts of accurate location data can be obtained via the use of this technique, animals can be followed for longer periods of time, little user intervention is required and data can be collected from areas in which the researcher cannot go (D'eon and Delparte 2005, Hemson 2002, Nilsen et al. 2008). The increased amount of spatial data obtained via this method results in higher accuracy of home range and habitat use estimates (Otis and White 1999).

There are however, problems associated with the collection of GPS telemetry data. Habitat, topography, satellite and vegetation coverage can all affect the amount of time it takes to acquire satellite positions and can limit the use of GPS tracking in areas with dense woodland and mountainous topography (Cargnelutti et al 2006, D'eon et al 2002, Di Orio et al. 2003).

3.3.1 Home range analysis

A number of different analytical methods are used to estimate home ranges of individuals (Nilsen et al. 2008). Two of the most commonly used methods are the Minimum Convex Polygon method (MCP) (Mohr 1947) and kernel density estimation (Worton 1989). MCP involves calculating the area enclosed by the imaginary lines that join the outermost location points visited by an animal. The area of the convex polygon

created is then measured and represents the individual's observed home range (Mohr 1947). MCP is used widely as it allows comparison with home range estimates from earlier studies that have been calculated in this way (Odden and Wegge 2005). However, despite its wide usage, it has been found to have areas of bias. The boundary of the calculated MCP encompasses all location fixes used in a home range study and includes occasional forays that an animal makes outside its core area. The resulting range size is strongly influenced by these outlying fixes (Harris et al 1990). MCP calculation is also biased by the sample size of location fixes meaning that bigger sample sizes produce larger home range estimates (Norton and Lawson 1985). In addition, an MCP may include areas that an animal never visits and does not give an indication of the intensity of home range use (Harris et al 1990).

Kernel density estimation (KDE) was adapted for animal home range analysis by Worton (1989) to estimate complex distributions from small sample sizes. It is considered by many researchers to be a much more accurate and reliable method for home range estimation than MCP (Borger et al. 2006, Harris et al. 1990, Nilsen et al. 2008, Odden and Wegge 2005, Worton 1989) and has become one of the most common home range estimators used in ecological studies. KDE is a contouring method that creates isopleths of intensity of home range usage via the calculation of the mean influence of data points at a range of grid intersections. Isopleths that are created by this method indicate the amount of time an individual spends within a contour (for example 95%, 75%, 50%) and contains a fixed percentage of the utilisation density of the location data used (Hemson et al. 2005). KDE provides a more accurate representation of spatial utilisation as it allows the inclusion of multiple activity centres as peripheral data fixes are not used to create home range boundaries. It is also less affected by outlying points and excludes unused areas of home ranges (Hemson et al. 2005).

The next section examines the data obtained via GPS telemetry on leopard home ranges in this study and discusses the implications of these results for leopard mortality rates and population sources and sinks in the Soutpansberg.

3.4 Methods

3.4.1 Live trapping and satellite collaring

Live trapping and collaring of leopards with GSM-GPRS satellite collars was conducted from June 2007 – Sept 2007 to obtain information on leopard home range use, mortality rates and population sources and sinks. Two leopards were captured and collared during this period – a female (F1) and a male (M1).

3.4.1.1 Live trapping

In order to place satellite collars on individuals, leopards were captured using live or box traps as shown in Figure 3.1. These traps were made of slim steel bars and were approximately 3m x 1m x 1m in dimension. The traps had one or two doors that opened at each end when set but closed when an animal entered the trap and tripped the closing mechanism. The mechanism was either a treadle plate which the animal had to step on to reach the bait or a metal lever or piece of string to which the bait was tied. The trap door closed when either the treadle plate was pressed or the bait lever was pulled forward. In this study three traps were used - two with a treadle plate and one with a bait lever. Only one door of each trap was left open for the leopard to enter and the bait was placed at the back of the trap and tied there or was attached to the tripping mechanism.



Figure 3.1: Box trap used for leopard trapping

The traps were baited with calf foetuses obtained from a local abattoir on a weekly basis. Traps were checked twice a day – in the morning (7am) to see if a leopard had entered the trap and in the late afternoon (5pm) to remove other animals that may have been attracted by the bait. As leopards on the project site were more habituated to vehicles than they were to pedestrians, trap checking was done via quad bike and binoculars to reduce stress to any captured individuals. Live traps were sited in dense vegetation close to roads and paths that were known to be frequented by leopards. These data were obtained from a track and scat survey undertaken before trap positioning. Traps were placed far enough from roads to minimise human and animal disturbance to individuals caught in the trap.

When a leopard was found in one of the traps, the local veterinarian was called to administer anaesthetic before the collaring procedure. A tiletamine-zolazepam combination was used to anaesthetise collared leopards, the amount used varied with the estimated weight of the leopard (3-5mg/kg) (Balme et al. 2007). Once anaesthetised, the

health of the animal was monitored and any surface skin injuries were treated. Body measurements and weight were then taken and data were gathered on body temperature, condition, parasite load, overall health and age of the leopard. In addition, photographs of the animal were taken for identification purposes. The collar was then fitted and the leopard was monitored from a safe distance until it had recovered from the anaesthetic and moved away from the capture site. Figure 2.6 shows one of the GPS collars fitted onto a male leopard.



Figure 3.2: GPS collar on male leopard

3.4.1.2 GPS telemetry

GSM-GPRS collars were used for this study. These collars enable multiple locations to be recorded daily from a collared animal without the need for physical location. Data can also be collected on many animals simultaneously and from areas inaccessible to researchers.

To obtain positional information, the GPS (global positioning system) transmitter within the collar locks onto satellites which then determine its position. The collars used were set to take 3 positions over a 5 hour (300 minute) period with a position taken every 100 minutes. When the third position was taken, the time was recorded from the satellite and data was set out to a nearby GSM network tower which then transmitted the signal over a GSM cellular network to the collar provider (HotGroup, South Africa) and a cellular phone. This information was transmitted in the form of GPS coordinates whenever the animal was in an area of telephone signal coverage. If no GSM coverage was available, the data and time were stored to be sent when a GSM signal became available. The collar also recorded the speed at which the animal was travelling, the altitude of its position and the ambient air temperature.

3.4.2 Data Analysis

GPS data obtained from the satellite collars were plotted in ArcGIS 9.2 (ESRI TM) using base maps of the study area. Home range sizes were estimated using the Home Range extension (HRE) for ArcView 3.2 (ESRI TM). Both 95% fixed kernel density estimates with the smoothing factor h least squares cross-validation (LSCV) and 95% minimum convex polygons were estimated for both individuals to allow comparison with previous studies.

3.4.3 Autocorrelation

GPS data for both leopards showed a high degree of autocorrelation. Autocorrelation is the lack of independence between pairs of observations at certain distances in time or space and indicates that the individual being tracked did not have time to move far enough before it was relocated or it displayed a repeated movement pattern (Legendre 1993). Independence of successive animal locations is a basic assumption of many statistical methods of home range analysis such as kernel density estimation and dependence of observations may underestimate true home range size (Swihart and Slade 1985). In order to reduce autocorrelation GPS fix data was sub-sampled at one GPS location per day closest to 12pm. Sub-sampling of data day did not eliminate temporal bias in the observations but data were not sub-sampled further to protect the biological significance of the data set.

3.5 Results

Two leopards were captured and fitted with GPS satellite collars during the study. On 25th August 2007 a 37kg adult female leopard (F1) was captured using a single door wire box trap. The leopard was immobilised and fitted with the GPS collar and monitored for 4 months from 25 August to 26th December 2007. During this time she was re-captured ten days after her initial capture on 5th September 2007. 169 GPS fixes were recorded for F1 with a successful fix rate of 41%. A second leopard (M1) – a sub adult male was captured on 11th October 2007 and was monitored for just under 6 months from this date to 6th April 2008 when his signal disappeared. 879 GPS fixes were recorded for M1 with a successful fix rate of 54%. M1 was 38kg in weight. His sub adult status was confirmed by examination of his teeth and reproductive condition. Table 4.2 provides details of leopard captures.

Table 3.2. Leopard Captures at Lajuma Environmental Research Centre, western Soutpansberg, June 2007 - October 2007

Leopard	Sex	Age	Weight	Date
F1	Female	Adult	37 KG	25/08/2007
M1	Male	Sub adult	38 KG	11/10/2007

3.5.1 Home range size

The home range of F1 was estimated at 13.9 km² (95% MCP) over the time period of monitoring and she had a 95% fixed kernel density estimate of 16.31 km² after data had been sub-sampled to one observation per day to reduce autocorrelation, see Table 4.3. Before sub-sampling the 95% fixed kernel density home range estimate of F1 was 15.59km². The home range of M1 was estimated at 514 km² (95% MCP) over the time period of monitoring and showed a 95% fixed kernel density estimate of 200 km² after data had been sub-sampled to one observation per day to reduce autocorrelation, see Table 3.3. Before sub-sampling the 95% fixed kernel density home range estimate of M1 was 160 km². Figure 3.3 shows the home range of F1 and M1 via 95% MCP.

Table 3.3. Leopard home range estimate

Leopard	Date	Successful GPS locations acquired	% of successful fixes	95% Minimum Convex Polygon	95% Fixed Kernel (LSCV) All results	95% Fixed Kernel (LSCV) 1 GPS fix per day
F1	25 th Aug - 26 th Dec 2007	162/396	41%	13.9 km ²	15.6 km ²	16.3km ²
M1	11 th October 2007 – 6 th April 2008	879/1623	54%	514 km ²	160km ²	200km ²

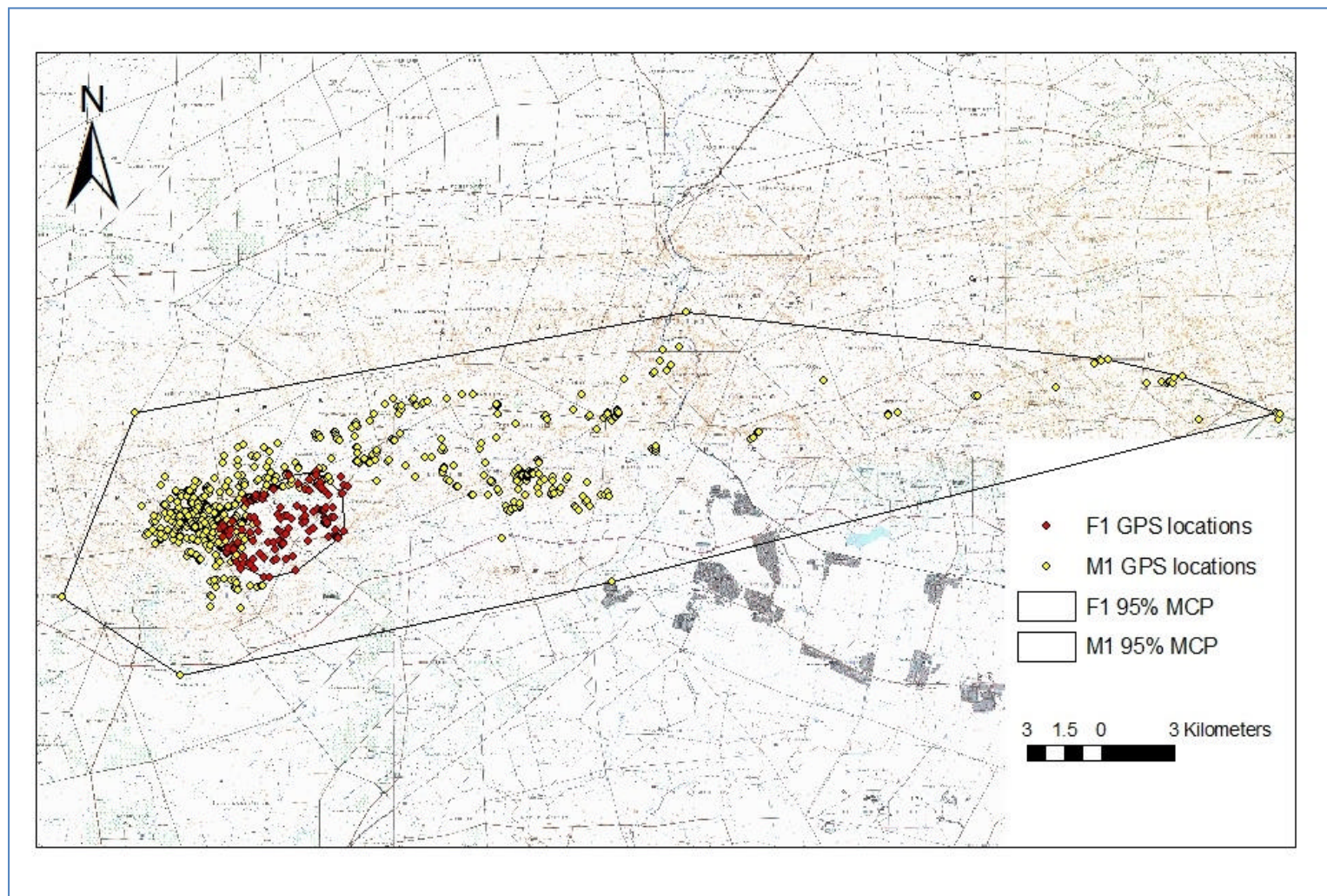


Figure 3.3 GPS locations and 95% MCP home ranges of collared leopards F1 and M1

3.5.2 Sub-adult dispersal

Figure 3.3 shows the ranging pattern of M1 during the 6 months that he was collared from the initial capture site to the last GPS location. From 11th October 2007 to the last signal date of 6th April 2008, M1 moved 52km from his initial capture location. Initially M1 remained close to his capture site, ranging on 6 different adjacent properties, 4 of these farms were either conservancy land or eco-tourism properties, one was a cattle farm and another communal land. On 3 occasions M1 made forays outside this area, possibly to investigate potential home ranges but quickly returned back to the area close to his capture site. Two of these forays were into community farm land, in areas where communities had mentioned that they had problems with leopards and the other was onto a cattle farm where the farmer admitted he regularly shot or poisoned leopards. On 25th February 2008 he made his final movement away from the site and did not return to the area around his capture location. The final GPS location of M1 was 52km away from his capture site on a property that was situated just 5km from the nearest large town, Louis Trichardt. M1's collar malfunctioned at this time and this was the last signal received from him.

3.5.3 Mortality

Female F1 was found dead on a neighbouring farm on 26th December 2007. After examination it was concluded that she died from complications due to collar wear. An autopsy showed no other physical signs that may have contributed to her death. The last GPS location signal from sub-adult M1 was received on 6th April 2008 and no further locations were received after this time. Camera traps were set up within the area to obtain further information regarding his condition and location but no photographs were obtained. It was concluded that GPS signals were lost due to collar malfunction. As M1's collar stopped working it was not possible to ascertain the fate of this sub-adult male. His last GPS signal was located very close to the largest town in the area. It is possible that M1 may have died here due to human induced mortality.

3.6 Discussion

3.6.1 Leopard home ranges

In comparison with other published home range estimates, the home range size of F1 was fairly small (13.9 km^2 - 95% MCP) and is closest in size to home ranges of female leopards measured in Kruger National Park (12.4 km^2 , Bailey 1993) and individuals from north-central farmland in Namibia (14.8 km^2 , Marker and Dickman 2005). These studies were conducted in thornbush or woodland savannah habitats. This indicates that the heterogenous, patchwork landscape of the Soutpansberg may be as productive as these areas and can hold higher densities of leopards than are found in other mountain ranges such as the fynbos mountains of Stellenbosch where leopards exhibit much larger home ranges and live at lower densities (487 km^2 , Norton and Lawson 1985). The small home range of this female suggests that the Soutpansberg is a prey rich area with prey densities high enough to allow leopards to live in large numbers and obtain enough prey to hold small home ranges. This conclusion is supported by the results from the camera trapping survey conducted during this study which provided a high leopard density estimate of 19 adult leopards per 100 km^2 .

The 95% MCP home range size of the male M1 (514 km^2) was much larger than that of the female F1 (13.9 km^2). This concurs with the results of other published studies on leopard home ranges with the great majority of male home ranges displaying larger home ranges than females as shown in Table 3.3. As previously discussed, male home range size is determined by the availability of reproductively active females and is often larger than females' ranges due to the need to maximise mating opportunities and have access to a number of females with which to mate (Bailey 1993, Marker and Dickman 2005, Mizutani and Jewell 1998). Male home ranges may also be larger than females' due to males' larger body size and accompanying increase in energy requirements (Carbone and Gittleman 2002). The relatively large size of M1's home range may also be due to the fact that he was dispersing away from the densely populated area of his capture site in order to establish a territory unoccupied by other males.

GPS location data showed that both leopards moved over areas in which they were protected (conservancy land and eco-tourism properties) and through cattle, game and

community land on which they would have been in danger from human persecution. The home range of F1 encompassed seven properties, three of which were conservancy land, one an ecotourism property, one was a cattle farm, one a game hunting farm where leopards were known to have been illegally shot and a property that belonged to a local community. M1 initially remained close to his capture site, ranging on 6 different adjacent properties, 4 of these farms were either conservancy land or eco-tourism properties, one was a cattle farm and another communal land. On 3 occasions M1 made forays outside this area. Two of these were into community farm land, in areas where communities had mentioned that they had problems with leopards and the other was onto a cattle farm where the farmer admitted he regularly shot or poisoned leopards. The movement patterns of both leopards brought them into contact with landowners and communities from almost all the different land use groups in the study area. As shown later in Chapter 5, attitudes and actions towards leopards differ greatly between different land use groups. Conservancy landowners and ecotourism operators tend to show the most positive attitudes towards leopards and a great tolerance of any game or livestock losses whereas cattle and community farmers display highly negative perceptions of them and actively engage in illegal leopard hunting and poaching.

3.6.2 Population sources and sinks

Due to the low capture success of leopards and the short duration of GPS tracking it was not possible to obtain detailed data on population sources and sinks across the study site as was planned.

F1 remained within the relatively small area of her home range (95% MCP 13.9 km²) during the study period and did not travel outside this area. She was captured on a property that was part of the local leopard conservancy and was found dead 2.5 km away on a hunting farm. As F1 probably died due to complications with her collar rather as discussed in the next section, data from her collar did not provide any information source or sink areas acting within the western Soutpansberg.

The movements of sub-adult male M1 however, may provide some preliminary evidence of local population sources and sinks. M1 was captured on a farm located within the leopard conservancy adjacent to the property where F1 was captured, and the last GPS signal received from his collar came from a farm located 52 km away very

close to a local town. His body was not recovered so it is not possible to say whether he died in that area or whether his collar stopped functioning. However, if M1 did die there due to human persecution which is likely due to the high human population density in that location, it may provide an example of the sink-source dynamics acting upon the Soutpansberg leopard population. Juvenile leopards may disperse from areas of high population density in the mountains where they are relatively well protected to vacant home ranges beneath the mountains where there is a much higher risk of human related mortality. If this is the case, Soutpansberg leopards is providing a source population for neighbouring areas where leopards are much more heavily persecuted.

Source-sink dynamics are particularly significant in areas where animals are legally harvested for commercial hunting (Novaro et al. 2005). It is important to be able to identify sink and source areas within a landscape in order to effectively manage species. Source populations may require increased protection from habitat loss and human persecution as they provide a supply of individuals for sink populations (Balme et al. 2010). Protection of sub-populations only located in sink areas may not be enough to protect meta-populations from decline. Wildlife management authorities need to consider the management of leopards on a landscape scale and may need to adjust trophy hunting quotas or permit allocations to account for the need for lower harvests in source areas. An examination of the causal factors behind sources and sinks such as the reason for increased mortality in sink areas can also provide information on the factors that are influencing increased mortality of individuals and can direct conservation efforts to address these specific issues.

3.6.3 Problems with data collection

Due to a low capture success rate only two leopards were GPS tracked during this study. The data obtained could therefore only provide limited information on leopard home ranges, mortalities and population sources and sinks. A larger sample size of leopards with a greater demographic range would be required to obtain more information on these factors. The mountainous topography of the study site also affected the percentage of successful GPS fix rates (F1 – 41%, M1 – 54% fix success rate). This factor may have had an effect upon the home range size estimated for F1 and the dispersal pattern of M1, possibly underestimating the true scale of their movements.

It was planned that a larger number of leopards would be collared. However, this was not possible due to problems with the collars that were used in this study. The satellite collars were produced by a South African company and due to errors in collar construction by the company were only available for use from June – September 2007. Once fitted the two collars worked and provided GPS telemetry data on the individuals collared. However, after F1 was captured 25th August 2007, on 26th December 2007 a neighbouring landowner called to say that he had found her body on his property. It was recovered and an autopsy showed that she had died recently and that her death may have been due to a reaction to the material of the collar as a burn was found along her throat area when the collar was removed.

Subsequent communication with the company that provided the collars and an ensuing investigation of photographs of F1 by a dermatologist suggested that she had died due to an adverse skin reaction to a chemical on the collars. The collar company stated then that they had coated the collar with a chemical used in car cockpits that had not been tested in the field and had not informed any of their customers that this had been done. Until the death of F1 the company were not aware of its harmful effects. After this incident the collars were no longer used and no further collaring of individuals was possible as the company were not able to provide safe alternatives.

3.6.4 Autocorrelation

Data obtained from GPS tracking showed a high degree of autocorrelation even after it had been sub-sampled to one fix per day. Data was not sub-sampled further in order to preserve its biological validity as autocorrelated clusters of GPS fixes may relate to a particular resource frequently utilised by the individual being tracked (Swihart and Slade 1985, Worton 1989). Autocorrelation of data may also have occurred due to the mountainous terrain of the study site where only some areas are open enough to acquire satellite positions.

3.6.5 Future work

Further information needs to be obtained via GPS telemetry on leopard home ranges, dispersal patterns and mortalities to establish whether the Soutpansberg is acting as a

source population for leopards in the surrounding habitat and to build up a picture of sources and sinks in the area.

Chapter 4. Leopard diets and human wildlife conflict in the Soutpansberg Mountains

4.1 Aims:

The aim of this chapter was to obtain accurate information on the spectrum of prey species taken by leopards in the Soutpansberg via scat analysis and combine these data with accounts of livestock predation events in order to examine differences between real and perceived leopard predation.

4.1.1 Questions:

1. What proportion of the diet of leopards living in a multi-use landscape of cattle, game and conservancy land is made up of livestock and game?
2. What are the perceived levels of human-wildlife conflict between landowners and leopards in the Soutpansberg and what are the differences between real and perceived leopard predation?

4.2 Introduction

Human-wildlife conflict is an issue of high conservation concern and has led to the global decline of many large carnivore species (Woodroffe et al. 2005). Incidences of human-wildlife conflict are also increasing with the expansion of human populations and agricultural activity into the habitats of wild animals (Treves and Karanth 2003). Conflict between humans and wildlife can be defined as a competition over resources or space and can take the form of threats to human life, economic livelihood, property or recreation (Treves and Karanth 2003). It can have significant negative impacts on both the humans and animals concerned. In the most serious cases it may involve livestock predation causing heavy economic losses for farmers and pastoralists or attacks on people leading to death (Thirgood et al. 2005).

Conflict between humans and carnivores is one of the main causes of negative attitudes towards large predators, reducing tolerance and leading to retaliatory killings (Woodroffe and Ginsberg 1998). For example, livestock predation by snow leopards has led to their widespread persecution by pastoralists in Nepal and India (Bagchi and Mishra 2006, Oli et al. 1994); jaguars are frequently killed by ranchers in South America for taking cattle (Conforti and Aze vedo 2003, Polisar et al. 2003) and cheetahs, lions and leopards are shot in retaliation for game and livestock predation across Africa (Kissui 2008, Ogada et al. 2003, Woodroffe et al. 2007).

Large predators such as the leopard are frequently in conflict with humans as they are obligate carnivores, have large home ranges, and are specialised for the predation of ungulate species (Carbone et al. 1999, Treves and Karanth 2003). This can lead them into conflict with farmers and pastoralists when individuals predate upon domesticated livestock or farmed game species.

4.2.1 Perceptions of leopard predation in the Soutpansberg

As discussed in Chapter 5, landowners in the Soutpansberg report losses of livestock and game due to leopard predation. Cattle and community farmers complain of leopard predation upon calves, sheep and goats and ecotourism operators and hunting farm owners report losses of farmed game species such as sable, blue wildebeest and waterbuck. The effect these losses have on landowner attitudes and actions towards leopards depends on whether they earn income from them via trophy hunting or ecotourism. Landowners that derive no economic benefit from leopards engage in illegal hunting and poaching activities whereas property owners that engage in trophy hunting or attract tourists to view leopards are willing to accept a certain level of loss of farmed game species.

4.2.2 Leopard diets

Leopards exhibit one of the broadest diet ranges of the larger predators and have been recorded feeding on 92 different species in sub-Saharan Africa alone (Hayward et al. 2006). This highly adaptable feeding behaviour is one of the main reasons that the leopard has such a wide geographic range and persists in areas long devoid of other

large carnivores (Bertram 1999, Norton et al. 1986). The breadth of prey species taken by leopards means that they can live wherever there is sufficient hunting cover and an appropriate prey base (Hayward et al. 2006).

Research on leopard diets has recorded a wide variety of prey items ranging from insects, small birds and rodents, catfish and hares to animals as large as giraffe calves and adult male eland (Hirst 1969, Kingdon 1977, Mitchell et al. 1965, Ott 2004 and Scheepers and Gilchrist 1991). Leopards require between 1.6 and 4.9 kg of meat per day to maintain their body mass (Bothma and Le Riche 1986, Bailey 1993, Stander et al. 1997) and studies have shown that to achieve this, leopards kill approximately 40 prey items per year in Londolozi Game Reserve on the border of Kruger National Park, 50 in Kruger National Park and 60 prey items in the Serengeti (Bailey 1993, Le Roux and Skinner 1989, Schaller 1972).

Hayward et al. (2006) undertook research into prey preferences of the leopard using 29 published and 4 unpublished studies of leopard diets from Africa and Asia. Using regression analyses of prey abundance estimates and leopard diet information, Hayward et al. (2006) discovered that leopards preferentially prey upon species with a weight range of 10-40kg but their most preferred prey items are species with a mean body mass of between 23 kg and 25 kg that are found in small herds, dense habitat and afford the lowest risk of injury during capture. As leopards mainly hunt via stalking or ambushing their prey, dense hunting cover is required in order to achieve a successful hunt. In Africa medium sized antelope such as impala, bushbuck and common duiker fall into this category and are significantly preferred by leopards as prey items (Hayward et al. 2006). Hayward et al. (2006) also found that other species such as warthog, porcupine and klipspringer were taken in accordance with their abundance but species such as plains zebra, blue wildebeest and baboon that are restricted to open vegetation or have significant anti-predator strategies are significantly avoided. Leopards were also found to take certain carnivore species such as cheetah, black backed jackal, civets and genets more frequently than expected.

4.2.3 Leopard diets in mountainous habitats

A number of dietary studies have been undertaken on leopards living in mountainous habitats in southern Africa (Grobler 1972, Nemangaya 2002, Norton et al. 1986, Ott et al. 2007, Power 2002, Schwarz and Fischer 2006, Stuart and Stuart 1993). Research conducted on leopards in the granite hills of the Rhodes Matopos National Park in Zimbabwe (Grobler 1972) found that hyrax, (*Procavia capensis*) and (*Heterohyrax brucei*), were the most frequently occurring prey in leopard scats (51%) followed by medium sized antelope such as impala and common duiker. Similar results were found by Norton et al. (1986) on examining leopard diets in the south western Cape Province in South Africa. They found that hyrax made up 52% of prey items taken in the area, with small to medium sized antelope such as klipspringer, grysbok and grey rhebok making up the second biggest group of prey species (37%). The high frequency of hyrax in the diets of leopard that live in montane areas suggests that leopards are partially active in the day in these habitats as hyrax are diurnal species and sleep at night in inaccessible holes (Schwarz and Fischer 2006, Stuart and Stuart 1993). In contrast to Grobler (1972) and Norton et al. (1986), Ott et al. (2007) in their study of leopard diets in the Baviannskloof Mountains of the Eastern Cape, found that medium sized antelope species such as mountain reedbuck, bushbuck and common duiker accounted for the majority of prey items taken by leopards (42.5%), with hyrax only making up 12.5% of the frequency of prey in leopard scats.

A few studies have been conducted on the dietary habits of leopards in areas of the Soutpansberg mountains and all have found similar results regarding the most frequently occurring prey items taken (Nemangaya 2002, Power 2002, Stuart and Stuart 1993, Schwarz and Fischer 2006). In three of these studies, hyrax were the most frequently occurring prey species in leopard scats at 43% (Stuart and Stuart 1993), 41.3% (Power 2002) and 33% (Nemangaya 2002). Schwarz and Fischer (2006) who collected leopard scats from the same conservancy property as Nemangaya, discovered that the most commonly occurring prey species in leopard scats were bushbuck (45.3%) and not hyrax as found by Nemangaya. This concurs with the findings of Hayward et al. (2006) that medium sized antelope are taken as significantly preferred prey items. However, all of these studies were confined to small areas of the Soutpansberg and the farms surveyed do not encompass the whole range of land use types as only one

conservancy property (Nemangaya 2002, Schwarz and Fischer 2006), one single cattle ranching area, and two game farms (Power 2002, Stuart and Stuart 1993) were sampled.

4.2.4 Livestock hunting leopards

As leopards are specialised to feed upon ungulates and are able to utilise a wide range of prey items, this can lead to individuals preying upon livestock and economically valuable farmed game (Treves and Karanth 2003). A number of factors can lead an individual to take livestock. Leopards may take domestic animals to fulfil energetic requirements when normal wild prey is scarce or may have learned that livestock are easy to catch, have less handling time than wild prey and fewer anti-predator strategies (Woodroffe et al. 2005).

Research undertaken on leopards living on a livestock ranch in Kenya by Mizutani (1995) found that dominant males in their prime killed more livestock than other leopards and that when a dominant male died, the social instability it caused attracted new leopards into the area who were also more prone to livestock predation. Mizutani also found that female leopards with cubs were more likely to stock raid than those without them, particularly if the core area of their home ranges or denning sites were in a habitat often used by sheep. In addition, Mizutani (1995) found that livestock were killed more frequently in densely vegetated habitat than in open savannah habitat.

Livestock management techniques can also affect the frequency of livestock predation events. In a study of the role of livestock husbandry on commercial and community ranches in Kenya, Ogada et al. (2003) found that livestock husbandry had a clear effect on rates of livestock depredation and the numbers of predators killed in retaliation. They found that livestock that were herded closely in the day, kept at night in bomas (a livestock enclosure), with watch dogs and a high level of human activity close to the boma were less likely to be killed by large carnivores. Woodroffe et al. (2007) also measured the effectiveness of traditional livestock husbandry in reducing predation by wild carnivores and discovered similar results. Woodroffe et al. (2007) found that the risk of predator attack by day was lowest for small herds that were accompanied by dogs and human herders and were grazed in open habitat. At night, the risk of attack was lowest for herds held in bomas with dense walls that were pierced by few gates.

Attack was further lowered where both men and domestic dogs were present near the bomas.

4.2.5 Livestock in leopard diets

A number of studies have been undertaken examining the predation impact of leopards living on ranch lands and multi-use agricultural landscapes in Africa (Grobler 1972, Mizutani 1999a, Nemangaya 2002, Norton et al. 1986, Power 2002, Ott et al. 2007, Schwarz and Fischer 2006, Stuart and Stuart 1993). Despite the fact that some leopards can and do take livestock, all of these studies found either no evidence of livestock in leopard diets as analysed by scat and kill analysis (Grobler 1972, Power 2002, Schwarz and Fischer 2006, Stuart and Stuart 1993) or that leopards took much less livestock than would be expected in relation to their abundance (Mizutani 1999a, Nemangaya 2002, Norton et al. 1986, Ott et al. 2007). Norton et al. (1986) examined leopard prey in areas surrounded by intensive farming activity. In their study they found that domestic livestock only made up a very small component of leopard diets (0.8%) despite the fact that high numbers of sheep were reportedly lost to leopards close to the areas where scats were collected.

Mizutani (1999a) in her research into the impact of leopards living on a cattle ranch in Laikipia, Kenya, found that leopards on the ranch did not rely on livestock as an important food resource even when both leopards and calves were found at relatively high densities (12.5 leopards and 26 calves per 100km²). Analysis of comprehensive records of livestock losses spanning 23 years showed that leopards had a much less adverse impact on livestock than might be expected considering their high density. On average leopards killed 6.6 calves and 11.8 sheep per year which represented only 1% of the biomass of potential livestock and was not enough to support the energy requirements of one leopard for a year. Analysis of leopard scats found that only 4.8% of scats analysed contained remains of calves. Mizutani concluded that the low predation impact of leopards on livestock was due to the presence of sufficient numbers of wild prey on the ranch which acted as a buffer against livestock losses to carnivores.

Ott et al. (2007) found similar results when studying leopard diets in the Baviaanskloof Provincial Nature Reserve and adjacent rangelands in South Africa in order to discover

the extent to which leopards preyed upon cattle in the area. Dietary analysis of leopard scats showed that the most important food source for leopards was small to medium sized ungulates such as mountain reedbuck, bushbuck, common duiker and grysbok which made up 42.5% of the frequency of prey items in leopard faeces. Only two scats (5%) contained domestic animals (one angora goat and a sheep) suggesting that domestic livestock only makes up a small component of leopard diets and that they do not preferentially prey on livestock.

Ott et al. (2007) also examined if leopard diets varied across the two land use types and whether the proportion of livestock in leopard diets was dependent on the availability and proximity of cattle to leopards. They found that although there was not a significant variation in the composition of prey species in leopard scats between the provincial nature reserve and on cattle rangelands adjacent to the reserve, there was a change in the frequency of prey species between the two areas. Leopards were found to prey more frequently upon medium and small sized ungulate species in both parts of the study area but in the rangelands a dietary shift was seen towards small mammals and birds. This was due to the reduced availability of larger wild ungulate species. The researchers did however, only use a small sample size of scats in this study ($n = 40$) and found that an asymptote was not reached when sampling efficiency was measured. A larger sample size of scats may have revealed further data about the spatial variation in leopard diets.

There has been a small amount of work conducted on the amount of livestock taken by leopards in the Soutpansberg but this shows conflicting results (Nemangaya 2002, Stein 2005). Nemangaya (2002) found that of the 249 leopard scats he examined only one scat contained calf remains (0.4%) suggesting that livestock in the Soutpansberg area are not an important component of leopard diets. However, Stein (2005) undertook a radio-tracking study of two male leopards in this area (home range estimation 45km^2) and found that one leopard killed at least 3 calves during the 5 month period of the study. Power (2002), on the other hand, examined leopard diets in one cattle farm and two game farms and found no evidence of livestock predation, as did Stuart and Stuart (1993) and Schwarz and Fischer (2006).

4.2.6 Predation of game species

Game farming for trophy hunting or ecotourism purposes has replaced cattle farming over much of southern Africa (Lindsey et al. 2005). This change in land use has implications for human-wildlife conflict between landowners and leopards. The result of the reduction in cattle farms is that incidents of cattle depredation have reduced, but leopard predation on farmed game species may have increased. Landowners base their choice of game on a number of factors. If the property is a hunting farm, landowners buy in game species that trophy hunters find attractive to hunt; these are often large, expensive antelope species such as male sable and roan. If the property is used for ecotourism purposes, species present on the land are chosen for their appeal to photographic tourists and purchasing them also involves a large financial outlay. Conflict can occur if leopards kill these economically valuable species. Therefore predation of medium sized antelope on game farms may be a particular source of human-wildlife conflict as they are in the preferred prey size class of leopards (Hayward et al. 2006).

Some studies have been undertaken on the effect of leopard predation on mortality in game species. Cronje et al. (2002) examined causes of mortality for four ungulate species from the collection of data on predator kill signs on a game ranch adjacent to Kruger National Park, South Africa. The study found that leopards were responsible for 21.3% of ungulate mortality after lions (and were responsible for the majority of all impala mortalities (41%), 11% of blue wildebeest deaths and 1.6% of kudu mortalities. Of blue wildebeest and kudu mortalities, leopards preyed upon sub-adult or juvenile individuals. However, death from anthrax infection across the four ungulate species was responsible for almost as high a percentage of mortalities as leopard predation (20.5%).

Power (2002), in his examination of leopard diets on three properties in the Soutpansberg mountains, two of which were game farms, found that only a small proportion of expensive farmed game were taken by leopards. On one of the game farms used for trophy hunting, 70% of the items occurring in leopard diets as shown by scat analysis and located kills were made up of hyrax, bushbuck and Jameson's red rock rabbit (*Pronolagus randensis*) whereas only 5.7% contained remains of antelope species used for trophy hunting (impala and kudu). Slightly more expensive game was found in

scats and kills on a neighbouring ecotourism property. Here the relative percentage occurrence of prey species in leopard diets included 4.7% kudu, 3.1% impala, 2.4% blue wildebeest, 1.6% red hartebeest and 0.8% eland. These species are normally bought in by the landowners as they no longer naturally occur in the Soutpansberg.

The next section outlines the methodologies employed to analyze leopard dietary composition in the study area and obtain information on perceived levels of human-wildlife conflict between landowners and leopards. These results are then examined to discover any differences between real and perceived levels of leopard predation in the Soutpansberg.

4.3 Methodology

4.3.1 Leopard Diet Analysis

Faecal analysis is a valuable method for determining predator diets (Hayward et al. 2006). To establish key prey species of leopards on the survey site, faecal samples were collected opportunistically across the study area from May 2007 to December 2008. Scat collection was conducted by myself and project assistants. Ten assistants worked on the project for differing durations of time. All scat analysis was conducted solely by myself. A total of 210 scats were collected during this period. Leopard scats were identified from their shape, size, placement and contents. Leopard scats are elongated in shape and often tapered at one end. They are generally found in several pieces which measure over 6 – 13 cm in length and 2.5- 4cm in diameter. Although scats can be smaller than 2.5 cm in diameter, they were not identified positively unless they were found in close association with adult leopard tracks (Henschel and Ray 2003).

African civet and hyena scats have similar proportions to those of leopards and may be mistaken for leopard scats. However, civet scats also contain arthropod exoskeletons, fruit and seeds and therefore could be differentiated from those of leopards (Henschel and Ray 2003). Hyena scats were distinguished from leopard scats as they are less elongated and often have a higher bone content giving them a chalky white colouration. Unlike leopards, hyenas also typically deposit their scats in prominent latrines and are

often found close to other hyena droppings by the sides of roads or trails (Henschel and Ray 2003).

Scats were not collected if there was any doubt regarding identification. Once identified the sample was placed in a plastic bag and the date, property on which it was collected and GPS location were noted on the bag. Scats were then washed in water using a sieve to remove soil, grass and leaves and were dried before all bones and hair were removed. Scat contents were then transferred to a plastic bag that was labelled with the sample's collection date, location and GPS coordinates. Any soft tissue found in the scat (e.g. flesh or cartilage) was placed in a vial of ethanol and included in the same bag.

Identification of prey remains in the scats was undertaken by the examination of the gross morphology of hair, teeth, nails, hooves, scales, and/or quills of mammals or feathers of birds and where needed was also examined under a microscope. These prey remains were compared to reference collections from Lajuma Environmental Research Centre, Field and Stream Taxidermists in Louis Trichardt, South Africa and the Iziko Cape Town Museum. Macroscopic analysis of bone fragments, teeth, nails and other body parts was undertaken at Iziko Cape Town Museum in concert with Dr Graham Avery of the Archaeozoology Department and was used to support hair analysis. Leopard diet was quantified from scat contents, using frequency of occurrence (percentage of scats in which a particular food item occurs), mean relative volume of a food item in scats, mean number of individuals in each scat and relative biomass ingested (Ray 2000).

Data on leopard diets were collected from twelve properties across the Soutpansberg (seven conservancy farms, one cattle farm, a community farm, a game farm used for hunting, an ecotourism property and a farm used for both game hunting and cattle farming). This represents the largest and most diverse range of properties sampled during a dietary study of leopards in the Soutpansberg. Leopard diets were quantified from scat contents, using frequency of occurrence (percentage of scats in which a particular prey item occurs) and relative biomass ingested (Ray 2000). Faecal analysis is a valuable method used for determining predator diets and can provide a range of

information on the feeding behaviour of large cats (Hayward et al. 2006, Karanth and Sunquist 1995, Putnam 1984).

Other methods have been used to obtain information on predator diets such as continuous follows which are considered one of the best ways of obtaining information on predators diets (Bertram 1979, Mills 1992). However, due to the elusive nature of leopards in the Soutpansberg and the dense and rocky vegetation, it was not possible to undertake this method of diet estimation. Analysis of predator kills can also be conducted as a means of assessing carnivore diets but finding kills in dense habitat is difficult and data can be biased towards larger prey items as smaller prey species are often consumed completely (Schwarz and Fischer 2006).

Leopard scats were collected opportunistically from roads and trails across the study area. Figure 4.1 shows a map of the GPS locations of leopard scats collected in the Soutpansberg. Once collected, scats were washed with water, filtered through a sieve and then air-dried. Hair, bone fragments and other keratinous material that had survived the digestion process (hyrax foot pads, miscellaneous teeth, claws, primate fingernails and ungulate hooves) were collected from the air dried scats and placed in numbered plastic bags.

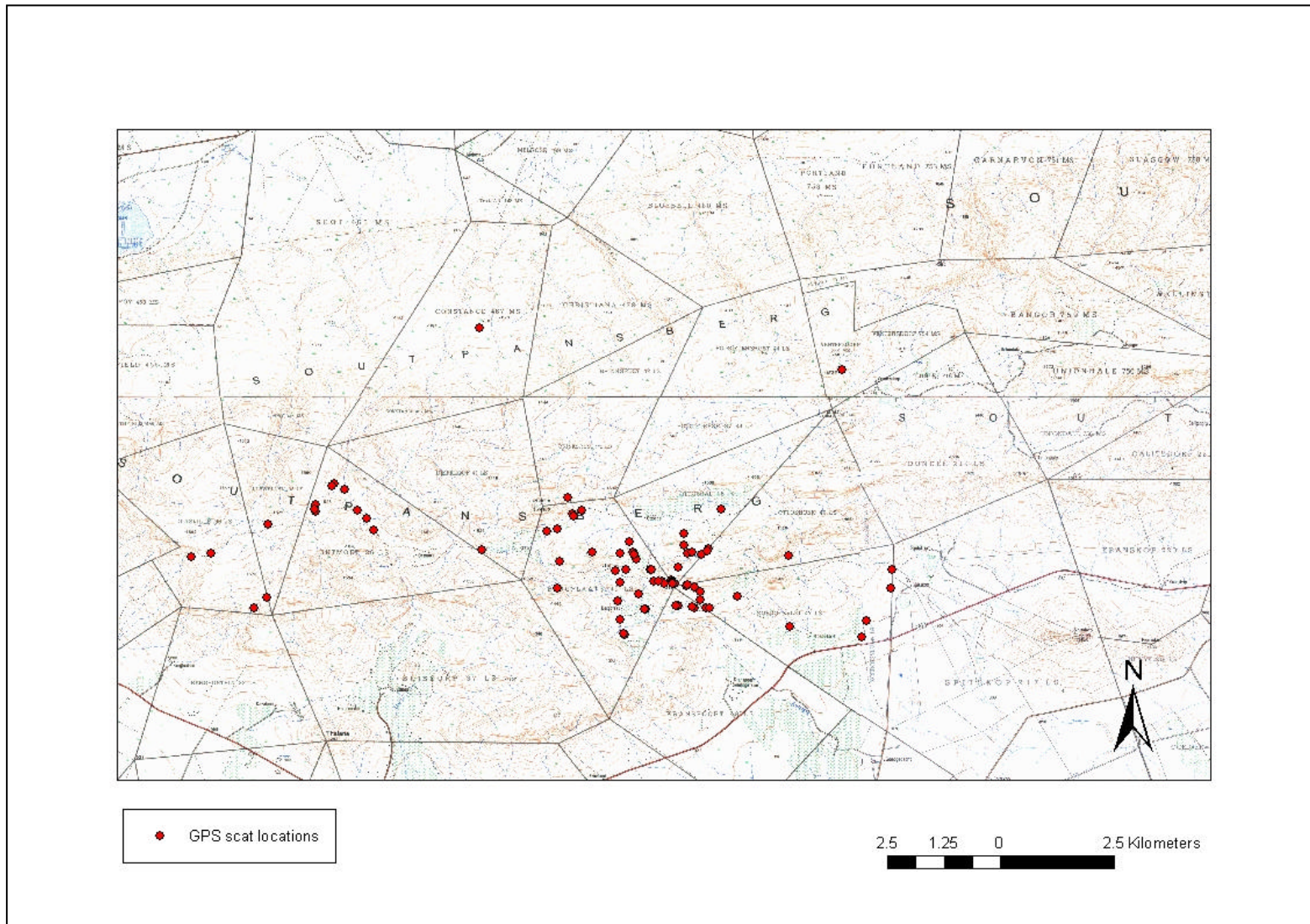


Figure 4.1 GPS locations of leopard scats collected in the Soutpansberg

Prey species were identified from all 210 scats by examining the gross morphology of bones and keratinous material. Due to time constraints only 100 scats were examined for prey contents via microscopic analysis of cuticle scale imprints and cross-sections of hairs. The 100 scats were randomly selected from the original 210 samples. Identification of bone fragments and teeth was made by comparison with reference material in the osteological collection of Iziko Cape Town Museum. Hyrax were often identified by the presence of their characteristic epidermal foot pads, teeth or bones, particularly the distal end of the humerus which has a distinctive supratrochlear foramen (Norton et al. 1986). Macroscopic identification of hair was possible with species such as the klipspringer that possess unique 'hollow' hairs (Norton et al. 1986, Stuart and Stuart 1993).

Cuticle scale imprints were made from the extracted hair samples using a method adapted from Keogh (1983). Clean microscope slides were thinly coated with PVA wood glue and hairs were placed in position on the slide using fine forceps. Ten hairs were randomly selected from each scat and placed on a slide. The slides were allowed to dry for approximately 5 minutes before the hairs were removed and the scale imprints were then viewed under a light microscope under 100x and 200x magnifications.

Cross sections of hairs were made using a method adapted from Douglas (1989). Random selections of 10 hairs were made from each scat sample and were placed in a disposable plastic pipette. The bulb at the end of the pipette was depressed to remove air and the tube was filled with molten beeswax. Once filled, the tubes were cooled at room temperature. The pipette was then cut into thin sections of approximately 1-2mm using a razor blade and approximately 10-15 of these sections were fixed onto microscope slides using molten wax. Slides were examined under a 100x and 200x magnification using a light microscope. Cross sections and cuticular scale patterns were made with hair samples from all possible leopard prey that occurred in the study area to serve as a reference collection. Hair cross sections and scale pattern imprints were then compared reference samples and published hair keys (Dreyer 1966, Perrin and Campbell 1980, Keogh 1983) to identify the type of prey involved.

4.3.2 Analysis

Known biases exist in dietary analysis resulting from the differential digestion rates of different sized prey items in scats (Putman 1984). Prey contents are frequently calculated via their frequency of occurrence (the frequency at which a certain species is found in relation to the total number of prey items in all scats). This can overestimate the importance of small prey items in leopard diets and occurs as small animals have a proportionally larger skin surface than larger species and are often devoured completely leaving a higher proportion of indigestible remains (Hayward et al. 2006, Mizutani 1999a). When large prey is taken, only the digestible meat may be eaten and fewer remains will be produced in faecal material.

Correction factors for the body size of prey species have been developed to prevent the overestimation of small prey items in scats (Ackerman et al. 1984, Floyd et al. 1978). Floyd et al. (1978) carried out experiments with wolves (*Canis lupus*) and calculated an index to compensate for the difference between the overrepresented small and underestimated larger prey animals. Ackerman et al. (1984) conducted feeding trials with cougars (*Felis concolor*) and found a linear relationship between the ingested biomass per scat and the live weight of the prey species. They then developed a modified formula from Floyd et al.'s (1978) work in order to calculate the share of biomass between small and large prey items in scats. Ackerman's index was used in this study under the assumption that the digestive system of leopards and cougars is similar. The number of faecal samples containing particular prey items was then converted into relative biomass in order to calculate the proportion of livestock and farmed game in leopard diets. Ackerman's Index:

$$Y = 1.98 + 0.035 X$$

Where X equals the mean weight of the prey animal and Y the intake of biomass in kg.

In order to calculate the relative biomass consumed, a corrected frequency of occurrence was used to take account of multiple prey species within a single scat as the quantity of meat consumed for a particular prey species decreases as the number of species in a scat increases (Henschel et al. 2005). A corrected frequency of occurrence

was obtained via dividing 1 by the number of prey species in the scat (Karanth and Sunquist 1995).

4.3.3 Prey availability

Point and line transects were attempted in the study area in order to obtain information on prey density and enable an analysis of leopard prey preferences. Due to the mountainous terrain of the Soutpansberg it was not possible to walk line transects or observe enough individual animals to conduct an analysis of prey densities therefore this information was not available.

4.3.4 Perceptions of human-leopard conflict

Data on predation events experienced by landowners were collected via semi-structured interviews and questionnaires as described later in Chapter 5. This information was gathered from 20 landowners and covered 23 properties (five cattle farms, five game hunting farms, three alternative income farmers, three properties of unknown land use type, two conservancy properties, two communal farms, two ecotourism properties and one small stock farm). Questions landowners were asked in order to gather data on predation events are shown below. A copy of the whole questionnaire can be found in Appendix 1.

Human-wildlife conflict

Have leopards caused any livestock/game losses on your property?

Yes/No

If so please describe each loss (time of day/night, type of animal, its age, cost and date):

.....

4.3.5 Comparison between perceptions of human-leopard conflict and prey composition from scat analysis.

In order to examine the difference between real versus perceived leopard predation of livestock and game, the relationship between the frequency of reported predation events and the contents of leopard scats were analysed. Statistical tests were conducted using SPSS for Windows 15.0. This comparison was made between properties on which scat had been collected (N=12) and those on which interview data on perceived leopard predation of livestock and game was available (N=20 properties). All of the 12 farms on which dietary material were collected were included in the interview survey. Ideally leopard scats would have been collected from all farms on which interviews were conducted but this was not possible due to problems of access on some properties.

4.4 Results

It was possible to identify the prey contents of 142 scats down to the order level via bone analysis. The results of this broad scale dietary analysis show that species from the orders Hyracoidea (39.1%) and Artiodactyla (38%) make up the vast majority of prey items in scats analysed (77.1%) as shown in Table 4.1. The next most frequently occurring prey order are primates (15.8%) with species from the orders Rodentia, Soricomorpha and the Carnivora only making up 7.1% of prey items.

Table 4.1 Results of bone analysis (n=142)

Order	Examples of species in this order	Count	Frequency of occurrence (%)
Hyracoidea	Rock hyrax	55.5	39.1
Artiodactyla	Bushbuck	54	38.0
Primates	Baboon	22.5	15.8
Rodentia	Porcupine	7.5	5.3
Soricomorpha	Shrew sp.	0.5	0.4
Carnivora	Caracal	2	1.4
Total		142	

4.4.1 Relative frequency of prey animals in leopard scats

100 leopard scats were microscopically analysed for prey contents out of a collection of 210. Six of these contained unidentifiable prey remains. From the identifiable scats (n = 94), 12 mammal prey species were detected. Bushbuck proved to be the most frequently taken prey item by relative frequency (43.1%) followed by hyrax (22.9%) and vervet monkeys (12.2%). These three species made up 78.2% of the total prey items consumed by leopards. It was not possible to differentiate between the two hyrax species present in the study site, the rock hyrax, (*Procavia capensis*) and the yellow spotted rock hyrax, (*Heterohyrax brucei*) therefore these two species were grouped together as hyrax as previous researchers have done (Stuart and Stuart 1993). Mountain reedbuck, thick tailed bushbaby, warthog and kudu calf were only found in single samples. No remains of members of the Lagomorph family, birds, reptiles or carnivores were found in the scats analysed. There was also no presence of livestock or expensive farmed game species (see table 4.2).

Table 4.2. Relative Frequency of prey items in leopard scat in the western Soutpansberg Mountains, South Africa (unidentified prey items not included).

Species	Count of occurrence	Frequency of occurrence	Relative frequency of occurrence
Bushbuck	44	40.5	43.1
Hyrax	27	21.5	22.9
Vervet	12	11.5	12.2
Porcupine	6	4	4.3
Common Duiker	5	5	5.3
Baboon	4	4	4.3
Red Duiker	3	2.5	2.7
Samango	2	2	2.1
Mountain Reedbuck	1	1	1.1
Kudu calf	1	0.5	0.5
Thick tailed Bushbaby	1	0.5	0.5
Warthog	1	1	1

4.4.2 Relative biomass of prey animals in leopard scats

Converting the results of the dietary analysis via Ackerman's Index (Ackerman et al. 1984) from relative frequency to relative biomass, increased the importance of larger prey items such as the bushbuck from 41.3% to 49.5% and reduced the importance of smaller species such as hyrax from 22.9% to 18.6% (see table 6.3).

Table 4.3 Biomass of prey in leopard scat in the western Soutpansberg Mountains, South Africa (unidentified prey items not included).

Species	Relative frequency of occurrence (%)	Weight (kg)	correction factor	relative biomass consumed %
Bushbuck	43.1	28	2.96	49.5
Hyrax	22.9	3.4	2.10	18.6
Vervet	12.2	4.1	2.12	10.1
Porcupine	4.3	15.4	2.52	4.2
Common Duiker	5.3	20.7	2.70	5.6
Baboon	4.3	15.5	2.52	4.2
Red Duiker	2.7	12	2.40	2.5
Samango	2.1	4.9	2.15	1.8
Mountain Reedbuck	1.1	28	2.96	1.2
Kudu calf	0.5	6	2.19	0.5
Thick tailed Bushbaby	0.5	1.13	2.02	0.4
Warthog	1	56	3.94	1.4

Artiodactyla accounted for 60.7% of the relative biomass consumed, hyraxes (Hyracoidea) made up 18.6% and the third largest group represented in the dietary analysis were Primates (16.5%). Rodents only made up 4.2% of the relative biomass of prey items.

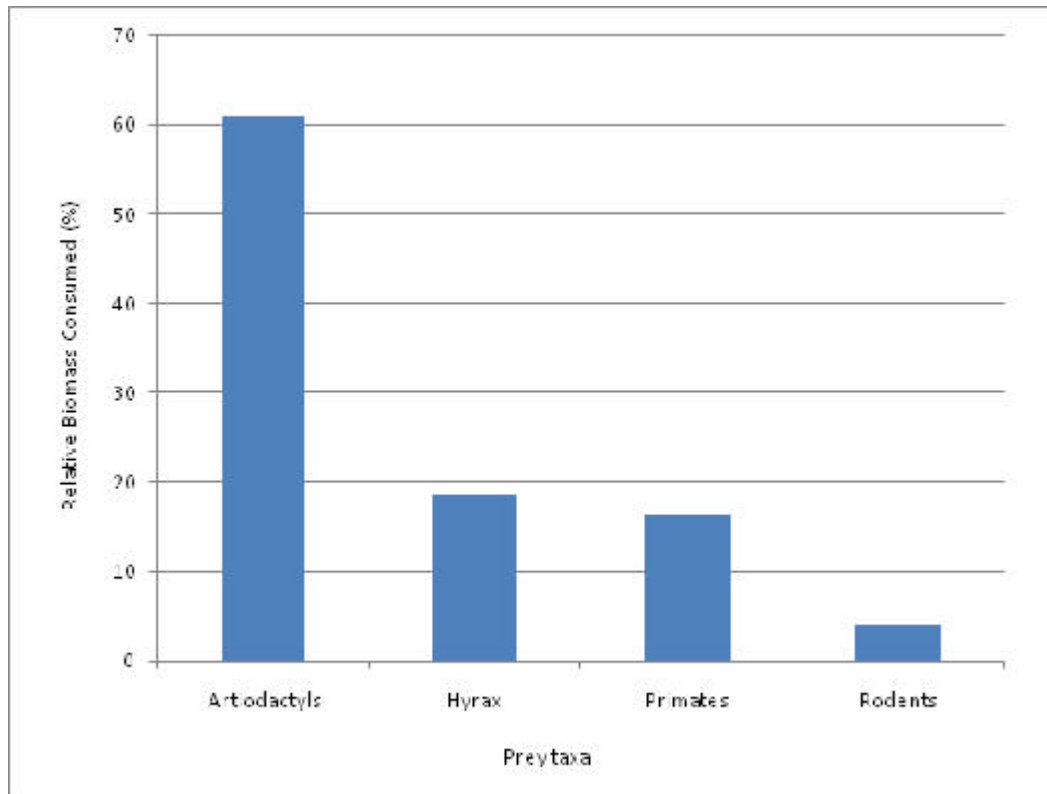


Figure 4.2 Relative biomass consumed of different prey taxa in the diets of leopards in the western Soutpansberg Mountains, South Africa.

As shown in Figure 6.2, medium sized animals such as bushbuck and common duiker in the weight range of 20 - 70kg made up just over half of the relative biomass consumed by leopards (57.7%), the next most frequently consumed prey size class by relative biomass were species in the very small size category (less than 5 kg) such as the hyrax (30.5%). Prey in the small size class only made up 11.8% of the relative biomass consumed and no species in the large prey category (heavier than 70kg) were found to be taken in this study.

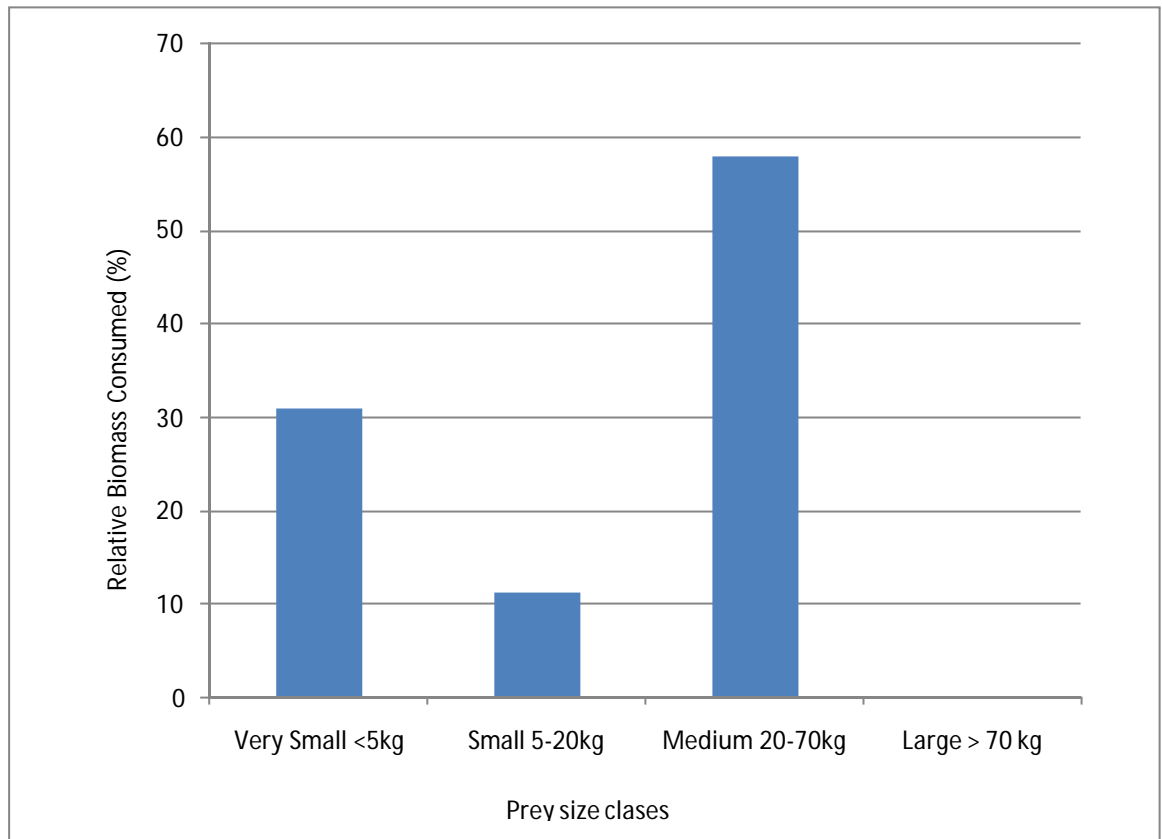


Figure 4.3 Relative biomass consumed of different prey size classes in the diets of leopards classes in the western Soutpansberg Mountains, South Africa.

4.4.3 Perceived predation events

From the data gathered from landowners (n = 20) on predation events by leopards on their own or neighbouring properties, cattle were most frequently mentioned as being killed by leopards (14 events) followed by impala (10 predation events). Other species that were most frequently mentioned were bushbuck (5 reports) and kudu (5), (see Figure 6.4).

After cattle, other livestock that were reported as being killed by leopards were goats (4 predation events), sheep (2 predations) and donkeys (1 event). Landowners also reported farmed game such as waterbuck, blue wildebeest, sable, eland, gemsbok and zebra as being killed by leopards on between 1 and 4 occasions.

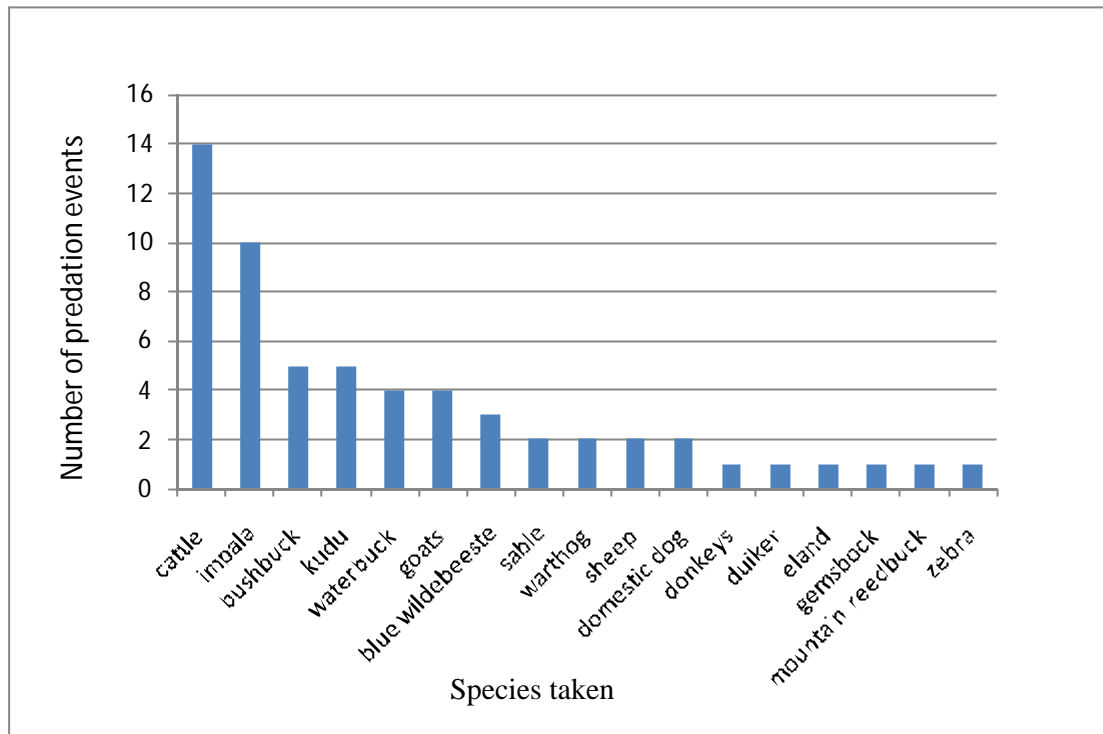


Figure 4.4 Predation events reported by landowners interviewed

Figure 6.5. provides a breakdown of species predation reports by land use type. This figure shows that livestock holders (cattle and community farmers) most frequently report losses of calves (64%) than other land use types, and game farmers (hunting game farm owners and ecotourism operators) are the only land use group that reports losses of expensive farmed game such as blue wildebeest and sable. Alternative income farmers and conservationists both report low levels of livestock and game losses.

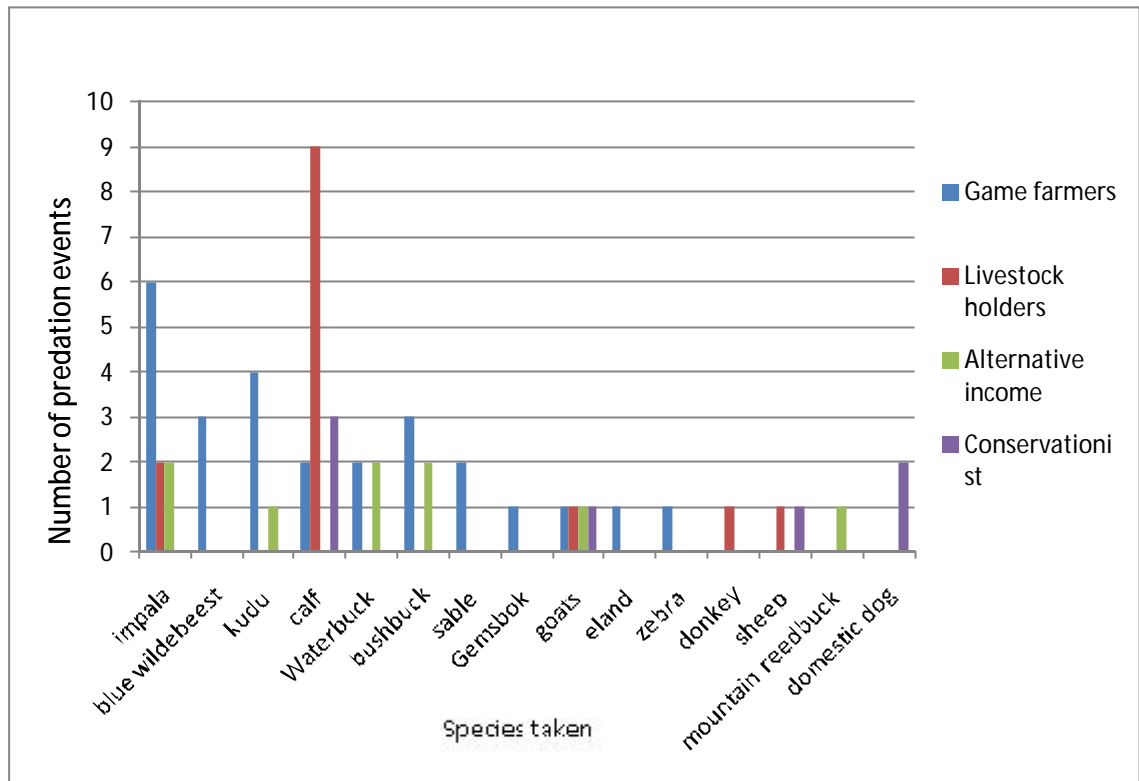


Figure 4.5 Species predation reports by landowner type

To examine the relationship between perceived leopard predation and species found in leopard scats, the correlation between the frequency of reports of predation by species and the frequency of species found in scats was assessed. Interestingly, a significant negative correlation was found between the frequency of reports of leopard predation by species and the frequency of species found in scats (Spearman Rho, $r_s = -0.482$, $N = 23$, $P = 0.020$). This result means that the species landowners most frequently report as being taken by leopards are very different from the ones that are most frequently found in leopard diets in the Soutpansberg. One of the main reasons for this is that landowners and farmers only mention predation of species that hold economic value for them such as livestock, whereas leopards mainly feed on species that hold low or no economic value such as bushbuck and hyrax. Landowners may also overestimate predation of livestock and expensive game. Figure 4.6 shows the differences between landowner reports of leopard predation and species found in leopard diets.

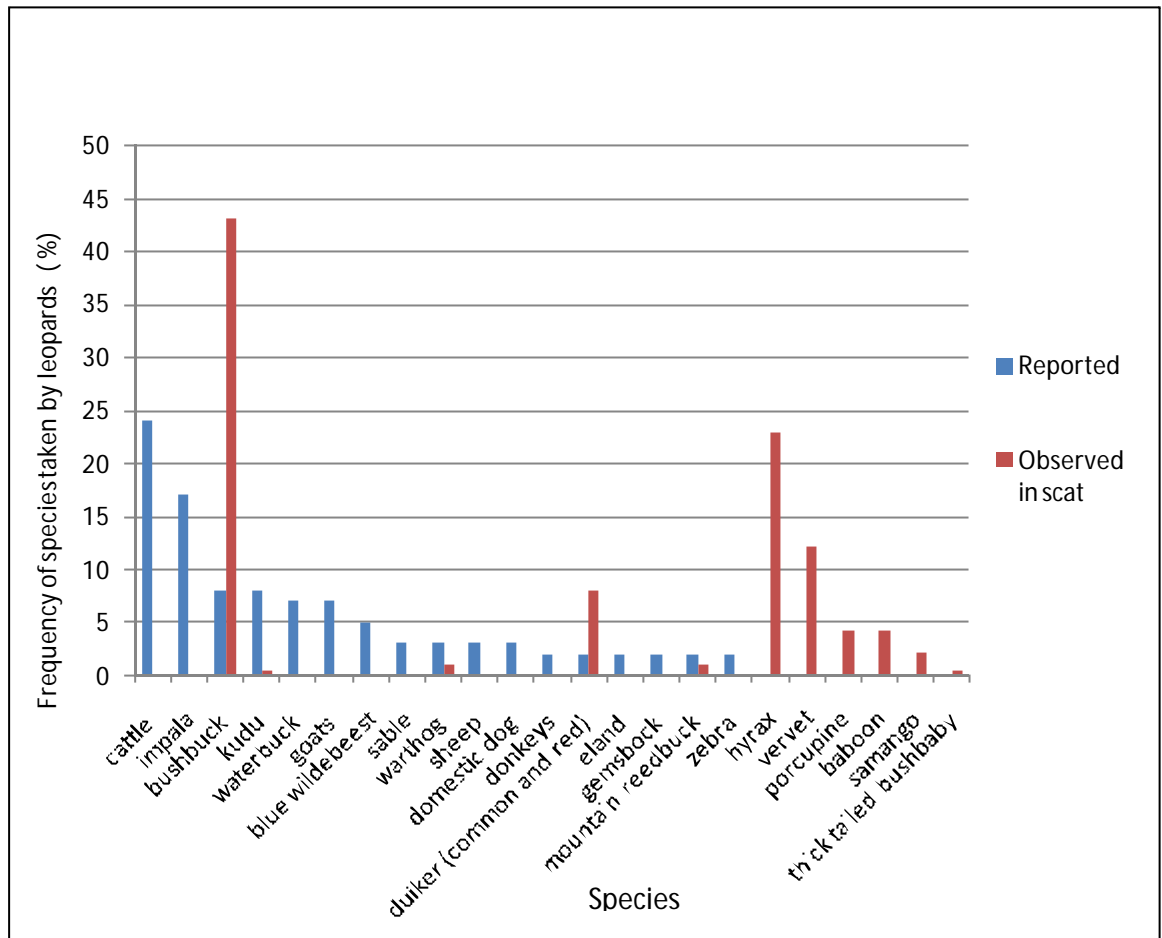


Figure 4.6 Graph showing the differences between landowner predation reports and species observed in leopard scats

As is shown in Figure 4.6, the four main species most commonly reported by landowners as being taken by leopards are cattle (24%), impala (17%), bushbuck (8%), and kudu (8%) but the four species most frequently found in leopard scats were bushbuck (43%), hyrax (23%), vervet monkeys (12%) and common and red duiker (8%). All of these species are naturally occurring in the Soutpansberg and have little or no economic value to landowners and some are even considered to be vermin (the vervet monkey).

4.5 Discussion

4.5.1 Prey spectrum

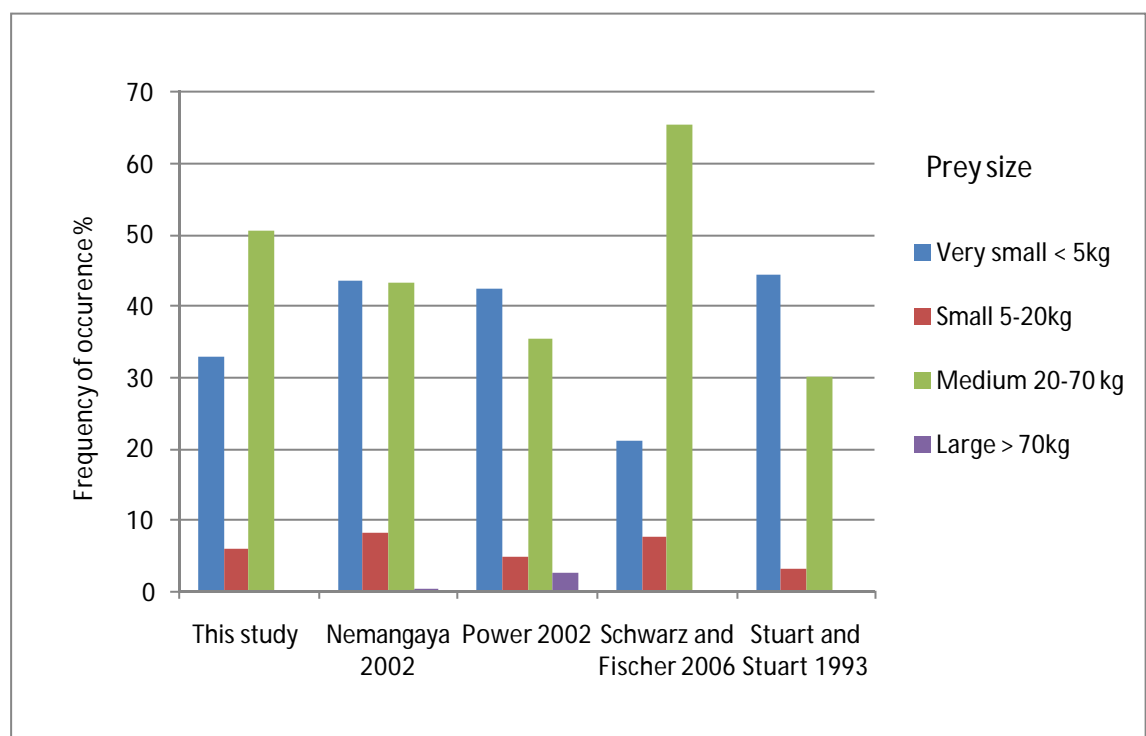
Twelve mammalian prey species were detected in the identifiable scats analysed in this study. This is the same number of species found by Schwarz and Fischer (2006) who examined the contents of 179 leopard scats from one conservancy property in the Soutpansberg. The range of prey items taken by leopards is however lower than three other dietary studies undertaken in adjacent areas in the Soutpansberg. Stuart and Stuart (1993) analysed 53 scats taken from an ecotourism property and found remains of 14 different species, Nemangaya (2002) found 17 species and Power (2002) found a much broader prey spectrum of 26 different prey items from an ecotourism property, a hunting farm and a cattle farm. Many of these species were found on the one ecotourism property that was not covered by this study due to access problems. Table 6.4 shows a comparison of dietary results between Nemangaya (2002), Power (2002), Schwarz and Fischer (2006), Stuart and Stuart (1993) and this study.

Six scats were unidentifiable and it is possible that they may contain further prey items not found in the other scats such as murids, shrews, small carnivores or lagomorph species. Stuart and Stuart (1993) found both scrub hare (*Lepus saxitalis*) and small rodents in leopards scats, Schwarz and Fischer (2006) found Jameson's rock rabbit (*Pronolagus randensis*) and giant rat (*Cricetomys gambianus*), and Power (2002) also found evidence of cane rats (*Thryonomys swinderianus*), certain murid species and 5.3% of the relative frequency of scats contained remains of Jameson's rock rabbit. Carnivores found in scat contents during these studies include African civet, aardwolf, caracal and water mongoose. The possibility of the unidentifiable scats containing any of these species was ruled out by the use of reference material. The six scats also do not contain livestock or expensive farmed game species as they were also examined against all relevant reference material.

Bushbuck proved to be the most frequently taken prey item by relative frequency (43.1%) followed by hyrax (22.9%), and vervet monkeys (12.2%). This is very similar to the results of Schwarz and Fischer (2006) who found bushbuck to be the most commonly consumed prey species (45.3%), then hyrax (11.2%), common duiker (11.2%) and vervet monkeys (10.1%). This result also concurs with findings of

Hayward et al. (2006) that bushbuck and common duiker are significantly preferred prey items as they have a mean body mass of between 23 kg and 25 kg. Figure 4.7 shows a comparison of dietary results via size class between Nemangaya (2002), Power (2002), Schwarz and Fischer (2006), Stuart and Stuart (1993) and this study. This figure shows that in 3 out of 5 of the studies, very small sized prey items were the most frequently size class found in leopard scats, followed by medium sized prey species (2 out of 5 studies). Large prey items were found only in two of the studies and at very low frequencies of occurrence.

Figure 4.7. Graph comparing the frequency of occurrence of prey items via size class in leopard diets from five studies conducted in the Soutpansberg



The relative frequency of antelope species such as bushbuck and common duiker and animals such as hyrax may follow the abundance of these species in the study area (Stuart and Stuart 1993). Bushbuck and hyrax were regularly observed at the study site. However, attempts to estimate densities of these species via line and point transects were unsuccessful due to the mountainous topography of the study site. As hyrax and vervet monkeys are diurnal species (Stuart and Stuart 1993) this suggests that leopards in the western Soutpansberg Mountains often hunt in the day-light hours.

4.5.2 Livestock and farmed game as prey in leopard diets in the Soutpansberg

Leopards are often seen as opportunists in their dietary behaviour which can sometimes lead then into conflict with landowners over consumption of livestock and expensive game species. However, analysis of leopard scats in this study found no evidence of livestock or expensive farmed game in leopard diets. Scat samples were collected from a number of properties that farm cattle, small stock and game such as sable, zebra, blue wildebeest and nyala but no remains of these species were found in the dietary material analysed.

The lack of livestock in the diets of leopards examined here agrees with the results found by other research conducted in the Soutpansberg (Stuart and Stuart 1993, Schwarz and Fischer 2006 and Power 2002). The only study that found any evidence of livestock in leopard scats was Nemangaya (2002) who found the remains of a domestic calf in 1 out of 249 scats (0.4%). This suggests that livestock are not an important part of leopard diets in the study area. These results also concur with other dietary studies of leopards living on rangelands, ranches or areas close to cattle farms (Mizutani 1999a, Ott et al. 2007, Norton et al. 1986). These studies found that leopards either did not predate on livestock in these areas or livestock made up a much lower proportion of the diet than would be expected. Livestock such as calves, sheep, donkeys and goats may not be important part of the diets of leopards sampled in this study because of the high abundance present of preferred prey species such as bushbuck and common duiker. No evidence of farmed game species was found in the scats analysed. This may have been due to the lack of access to certain ecotourism properties that were examined by Power (2002) who found remains of four farmed antelope species there – blue wildebeest

(2.4%), eland (0.8%), hartebeest (1.6%) and impala (3.5%). This suggests that small levels of farmed game can be taken by leopards in the Soutpansberg.

4.5.3 Perceived human-wildlife conflict between landowners and leopards

Although no livestock was found in the scat analysis, many landowners reported cattle predation events caused by leopards. Killing of cattle was the most frequently reported predation incident amongst the landowners interviewed. Goats were also reported as being taken by leopards, as were sheep and donkeys. Expensive farmed game such as sable, blue wildebeest, zebra and gemsbok were also reported as being preyed upon by leopards. One ecotourism operator stated that most of her sable calves were killed annually and that all of her young blue wildebeest were taken by leopards. Another ecotourism property manager said that 65-70% of all zebra and blue wildebeest calves were killed each year. Impala were also commonly reported as being taken by leopards. A cattle farmer also said that leopards had taken 350 out of his herd of 400 individuals and a hunting game farm manager stated that on average leopards eat 52-104 impala per year (1-2 per week). Other farmed game such as eland and waterbuck were reported as being killed by leopards.

It is possible, that some problem animals that do predate upon livestock or expensive game species may have been missed in the survey as scat collection did not cover all of the properties on which the interview survey was conducted. The comparison between real and perceived human-wildlife conflict between landowners and leopards was made between 12 farms on which scat had been collected and 20 farms from which interview data on leopard predation of livestock and game was available. As stated earlier in this chapter, it was planned that leopard scats would be collected from all farms on which interviews had been conducted. However, certain landowners would not grant access to their properties for scat collection therefore this was not possible. Despite this difference in the collection of scat and interview data, the lack of livestock in the diets of leopards examined here concurs with the results found by other dietary studies conducted in the Soutpansberg (Stuart and Stuart 1993, Schwarz and Fischer 2006 and Power 2002).

The next section will analyse the reasons for the gap that exists between real and perceived leopard predation of livestock and farmed game species.

4.5.4 The gap between real and perceived predation by leopards

The results show a large discrepancy between actual and perceived predation of livestock and farmed game. The wide discrepancy between reports of livestock and expensive game predation and the presence of these species in leopard scats may be due to a number of factors such as mistaken carnivore identity, misattribution of cause of death and may also be attributed to the socio-cultural and economic context in which the landowners themselves live which can prejudice their views of predators. Another reason for this gap is that landowners and farmers may only mention predation of species that hold economic value for them such as livestock, whereas leopards mainly feed on species that hold low or no economic value such as bushbuck and hyrax.

Research into actual versus perceived predation has shown that carnivores and other wild animals involved in human-wildlife conflicts are often blamed by farmers and pastoralists for more losses than they actually cause (Conforti et al. 2003, Gussett et al. 2008, Knight 2000, Marker et. al. 2003, Mishra 1997, Oli 1994, Naughton Treves 1997, Rasmussen 1999, Sillero-Zubri and Laurenson 2001). Rasmussen (1999) in his study of livestock predation by wild dogs in Zimbabwe found that cattle ranchers attributed losses of livestock to wild dogs when they had occurred due to cattle rustling and poaching. Rasmussen concluded that the presence of predators provided an excuse for herdsman to explain missing livestock and hide cattle poaching which claimed much more livestock in Zimbabwe than carnivore predation.

One of the reasons for the observed difference between recorded and perceived livestock and game predation may also be mistaken carnivore identity. Sympatric predators such as caracals, black-backed jackal and feral dogs all exist in the study area and are capable of killing calves, goats and sheep. Therefore deaths that have been attributed to leopards may have been caused by other predators (Ott et al. 2007). A manager of one of the properties who was interviewed in this study commented that “caracal and jackal can also be a problem with livestock, they take newborn calves and leopards are often blamed for the livestock losses caused by these species.”

4.5.5 Misattribution of cause of death

In addition, landowners, farmers and pastoralists may misattribute the causes of death of their livestock and game. Animals may have died of disease, been stolen or lost but causes of death can be mistakenly assigned to carnivore predation. In her study of the production system of a cattle ranch in Kenya, Mizutani (1999b) found that losses of livestock to disease were twice as high as the total annual losses due to carnivore predation and the number of livestock that were stolen or went missing on the ranch was similar to losses due to carnivores. In a survey of livestock production in community group ranches, Mizutani (1995) found that if livestock losses occurred due to theft or animals were missing, herders were more likely to blame predators than other causes particularly if these losses were due to their own negligence. Kissui (2008) gathered data on livestock management by pastoralists in Northern Tanzania on community ranches and also found in his analysis of livestock predation by carnivores that disease killed far more livestock than predation by lions, leopards and spotted hyena.

4.5.6 Socio-cultural and economic reasons

As discussed in Chapter 5 on social perspectives on the leopard, human-wildlife conflict and conservation, variation in attitudes toward large carnivores is partly based on the extent to which they conflict with human interests but is also affected by inherent prejudices of landowners and farmers (Kellert 1985). These prejudices are shaped by the socio-cultural and economic context in which farmers live.

Quantitative research on attitudes towards carnivores shows that the extent to which people tolerate wildlife damage is influenced by socio-economic factors such as wealth, education, age, nationality, sex and the financial impact of wildlife associated costs (Conforti et al. 2003, Ericson and Heberlein 2003, Gussett et al. 2008, Kaltenborn 2006, Kellert 1995, 1996, Naughton-Treves et al. 2003, Williams et al. 2002, Zimmerman et al. 2005). These studies demonstrate that people that tend to hold negative attitudes towards carnivores work in resource dependent professions such as farming, live in rural communities and carnivore ranges or have been affected by economic losses due to predators (Kaczensky et al. 2004).

Negative perceptions of carnivores may also be due to inflated perceptions of risk that often outweigh economic damage and drive retaliatory behaviour (Knight 2000, Naughton Treves et al. 2003). These perceptions may relate to the highly charged beliefs associated with large carnivores that have the ability to cause significant damage that can have severe emotional, financial and political consequences on farmers (Kellert et al. 1996, Treves et al. 2006). Such associations are shaped by catastrophic or costly events such as the predation of a large number of calves within one night (Treves et al. 2006).

As discussed later in Chapter 5, studies on farmer and landowner attitudes towards carnivores have found that experiencing a lack of control over one's life (external locus of control) and a feeling of not being able to influence policies about resource management, or even comprehend them, can negatively affect rural perceptions of predators (Bjerke et al. 2000, Kleiven et al. 2004). This is another reason for inflated perceptions of the damage that leopards cause to livestock in the Soutpansberg. As previously stated, the process of dealing with suspected livestock killing predators by governmental wildlife authorities is inefficient. Cattle farmers in particular are left to deal with livestock losses alone without the support of local authorities. Another factor contributing to negative perceptions towards leopards in the Soutpansberg is the prohibition against trophy hunting of damage causing leopards, which deprives cattle farmers of legal means to recoup losses to carnivores. This can lead farmers to feel an even greater sense of loss of control over their resources.

Social identity and occupation in rural communities also affects attitudes towards carnivores (Naughton Treves et al. 2003). These attitudes are connected to individuals' lifestyles and once established become deep rooted. Within these specific social groups or professions, members share a social environment that reinforces their value laden attitudes towards wildlife and fosters a sense of shared values and goals (Naughton Treves et al. 2003). As previously mentioned, livestock farmers in the Soutpansberg are a very distinct social group, many are older farmers who have lived in the area for generations and support and act on the idea that if an animal gives them a problem they should destroy it. For them nature is something that has to be fought against and overcome in order to earn a living. Strength of feeling against the leopard as a problem animal is in part to do with membership of this distinct social group whose deeply

ingrained negative attitudes towards wild animals have been handed down for generations.

Interviews with landowners who farm game species for trophy hunting or ecotourism purposes also revealed discrepancies between real and perceived predation of game by leopards as shown in Figure 6.6. These landowners reported losses of expensive game such as sable and blue wildebeest but these species were not found in leopard scats. One of the main differences between game and cattle farmers is that these perceived losses from carnivores do not drive retaliatory actions towards leopards to the same extent. The reason for this may be that due to their ability to trophy hunt leopards on their properties; they consider them to have a financial value and can accept much heavier real or perceived losses. As mentioned previously, an ecotourism game landowner reported that every year she lost all her sable calves to leopards but gains money from tourists coming to see leopards and so therefore not view them as problem animals. Data from this and other research on leopard diets in the Soutpansberg suggests leopards may not predate upon sable calves but because of the economic value leopards have to this landowner, she chooses not to persecute them despite her perceptions of leopard predation.

4.5.7 Solutions

The large gap between real and perceived predation of livestock and game is a serious problem as it affects landowner actions towards predators and any retaliatory measures taken against leopards due to perceived predation can contribute to population declines.

A number of solutions may help to close this gap. Research has shown that education can improve tolerance towards carnivores (Lindsey et. al. 2005, Woodroffe et al. 2005). This could involve training landowners to recognize the tracks of different carnivores to enable them to correctly identify the species of stock raiders. Livestock predation can also be considerably reduced by improved livestock husbandry techniques (Kissui 2008, Ogada et al. 2003). Landowners could be educated regarding the best ways to prevent livestock predation such as kraaling calves at night, using livestock guarding dogs and ensuring that domestic animals are accompanied by humans when grazing.

There are also ways in which farmers' feelings of loss of control over their resources and environment can be improved. During the course of this study camera traps were used to calculate the density of leopards in the area. Landowners who had cameras on their properties found that having access to their wildlife via digital photography gave them an improved sense of ownership. Many also asked where they could purchase their own cameras. The use of camera trap photography could be used to identify and track individual problem animals where they exist and assist in cases of mistaken carnivore identity. For example, camera trap photographs may provide evidence that feral dogs had been attacking calves rather than leopards. Institutional improvements could also provide a solution to landowners' perceptions of leopards as pests via improved government response to livestock predation and a serious examination of the possibility of the trophy hunting of verified problem animals in order to compensate livestock owners for losses.

As has been shown in this chapter, landowners and farmers perceive leopards as stock raiders that predate upon cattle and expensive game. For some landowners, this perception fuels retaliatory behaviour towards leopards. The next chapter examines the potential for trophy hunting to be used as a conservation tool for leopards by providing economic incentives to landowners and farmers to obtain money from commercial leopard hunting in order to reduce illegal hunting of the wider population.

5: Social perspectives on the leopard, human wildlife conflict and conservation

5.1 Aims

This chapter examines the perceptions and attitudes of landowners and farmers in the Soutpansberg Mountains towards leopards, leopard conservation and human-wildlife conflict and explores the way in which their associations with leopards vary according to membership of different social groups and land use categories.

5.2 The Soutpansberg Community

As described in Chapter 1, the Soutpansberg community is ethnically and culturally mixed and comprises black Africans, Afrikaners, South Africans of British descent and a small number of racially mixed people. Languages spoken in Makhado are principally Venda and Shangaan (Tsonga), with Afrikaans, English and Pedi (Northern Sotho) spoken by smaller groups (Lahiff et al. 2006). The majority of the population are Venda and live in either small scale subsistence farms or in the old Venda 'homelands' (Lahiff et al. 2006). Afrikaners and South Africans of British descent inhabit either the town of Makhado or the surrounding commercial farms on one side of the town. The next section provides information on socio-economic and cultural backgrounds of the different ethnic groups in the Soutpansberg.

5.2.1 The Venda People

Before the arrival of the first European settlers in the early 19th century, the Soutpansberg Mountains were inhabited by San hunter-gatherers and Venda-speaking peoples (Gaigher et al. 2001). Based on Venda genealogies, historians argue that the Venda arrived at the end of 17th or beginning of 18th century but artefacts made in Venda style have been found in the Soutpansberg dating from approximately 1370 (Thompson 1990).

The Venda people make up the majority of the rural population in the Makhado area and share a common language also known as Venda (Rosmarin 2008). The Venda have

their own rich, distinct culture and customs and were the last cultural group in the Soutpansberg to be affected by colonial rule (Macdonald et al. 2003). Traditional affairs in the Venda are managed by Chiefs and Headmen and Venda leadership structures cover the whole Vhembe area and provide an informal institutional organization (Vhembe District Municipality 2007).

The Venda rural community is extremely poor with high levels of economic deprivation and unemployment, which is estimated to be around 28% (Lahiff et al. 2006). The majority of the rural black population are women between the ages of 15 and 65. This can be attributed to the fact that many men are involved in migrant labour (Lahiff et al. 2006). Income in the community is derived from communal subsistence farming of cattle and small stock such as goats and many people rely on local plants to supply grazing, fuel, timber and agricultural needs. As well as providing income, cattle play a highly important cultural role in Venda society as they are used in cultural institutions such as bridewealth. Bridewealth occurs when the father or relative of a Venda man who wishes to marry pays a *lobola* (brideprice) in the form of cattle to the bride's family (Kuper 1979). Once this has been paid, the person who paid the price is then responsible for the welfare of the bride. Bridewealth creates a debt that must be repaid by a marriage which will return the cattle to the family that originally paid them (Kuper 1982). The cultural implications of the importance of cattle in Venda culture and the effect this may have on Venda perceptions of the leopard as a predator of cattle are explored later in this chapter.

5.2.2 The Afrikaner Community

The Afrikaner community in Makhado Municipal District are related to the first European settlers that came to the Soutpansberg in 1836 as part of the Great Trek. Afrikaners live either in Makhado town or on the surrounding commercial farms. Afrikaners speak their own language, Afrikaans, which is mainly derived from Dutch. Afrikaners in the region are also known collectively as 'Boers', the Afrikaans word for farmer, and refers to their heritage as descendants of Dutch speaking settlers.

Afrikaners first settled in the Soutpansberg in 1848 when the town Schoemansdal was founded at the foot of the Soutpansberg (Muller 1981, Thompson 1990). Schoemansdal

was set up as a centre for elephant hunting and soon became the local hub of Boer life (Muller 1981). In the 1860's, the Venda chiefdoms temporarily managed to turn the tide of Afrikaner settlement attacking Schomansdal which was subsequently evacuated and resulted in almost all Afrikaners abandoning the Soutpanberg (Thompson 1990, Wilson and Thompson 1971). During the 1880's Afrikaners resettled the area and in 1890 a series of expeditions were led against the Venda in order to destroy their strongholds (Wilson and Thompson 1971). White settlement did not reach the upper parts of the mountain range, until the first white landowners were given land titles there from 1880. Afrikaners make up a small minority of the population in Makhado Municipal District but have a higher standard of employment, living conditions and income than the majority of the black population due to the socio-economic legacy of the Apartheid regime which led to an inequality of skills and education between blacks and whites (Vhembe District Municipality 2007). In the Soutpansberg, Afrikaners are predominantly involved in the ownership and management of commercial cattle ranches.

5.2.3 The Buys Community

The Buys community is the only racially mixed community in the Soutpansberg (termed a 'coloured community' in South Africa). This community lives at the base of the western Soutpansberg Mountains in Buysdorp ('Buys town'). Buysdorp covers an area of 110km² of land and is made up of 300 individuals descended from Coenraad de Buys (De Jongh 2006). De Buys was the great-grandson of French Huguenot Jean du Bois, who arrived at the Cape in 1688 and married or cohabited with several indigenous women. He was granted the tract of land now known as Buysdorp in 1888 by President Paul Kruger for services to the Transvaal Republic. Buysdorp is made up of four farms divided into 260 allotments used for agriculture (maize and vegetables) and communal grazing (De Jongh 2006). The community has a strong ethnic and cultural identity and Buysdorp town has its own roads, churches, a school building, shops, a police station and cemetery (De Jongh 2006).

5.2.4 British South Africans

Another cultural group present in the Soutpansberg are English speaking South Africans. Many are descended from British settlers in South Africa. English speaking South Africans are characterised by high education, skill and income levels in comparison to the black community and professions amongst this group in the Soutpansberg include commercial hunting farm managers and ecotourism operators.

5.3 Land use in the Soutpansberg

Land in the Soutpansberg and surrounding area is made up of a patchwork of community, game and cattle farms, ecotourism and conservation areas. In recent years the majority of cattle farms in the Soutpansberg area have been converted into game farms for hunting or eco-tourism purposes (Weisser et al. 2003). These commercial game farms are used to farm a high diversity of game species for the trophy hunting or ecotourism industry. In recent years the majority of cattle farms in the Soutpansberg area have been converted into game farms for hunting, eco-tourism or conservation with an 84% decline in cattle numbers in arid areas of the province between 1975 and 1995 (Hahn et al. 2003). This shift in land use came about due to the introduction of legislative changes in the 1960's which granted farmers ownership of wildlife on their land and the right to its consumptive use (Lindsey et al. 2006). The decreasing profitability of cattle farming further encouraged the shift from livestock ranching to wildlife ranching (Cousins et al. 2008).

Game farming involves the management of game species on fenced, private or communal land. A high diversity of game species are managed for purposes such as trophy hunting, live trade, wildlife meat or ecotourism (Cousins et al. 2008). Game farming is a significant contributor to the provincial and national economy and generates revenues of \$100 million annually (Lindsey et al. 2007). In 1998 there were approximately 2300 game ranches covering 3.6 million hectares in Limpopo Province (van der Waal and Decker 2000). This method of farming has also contributed to the recovery of a number of game species and the area has more game than it did 100 years ago (Lewis and Jackson 2005). Figure 5.1 shows the patchwork nature of land use in the Soutpansberg.

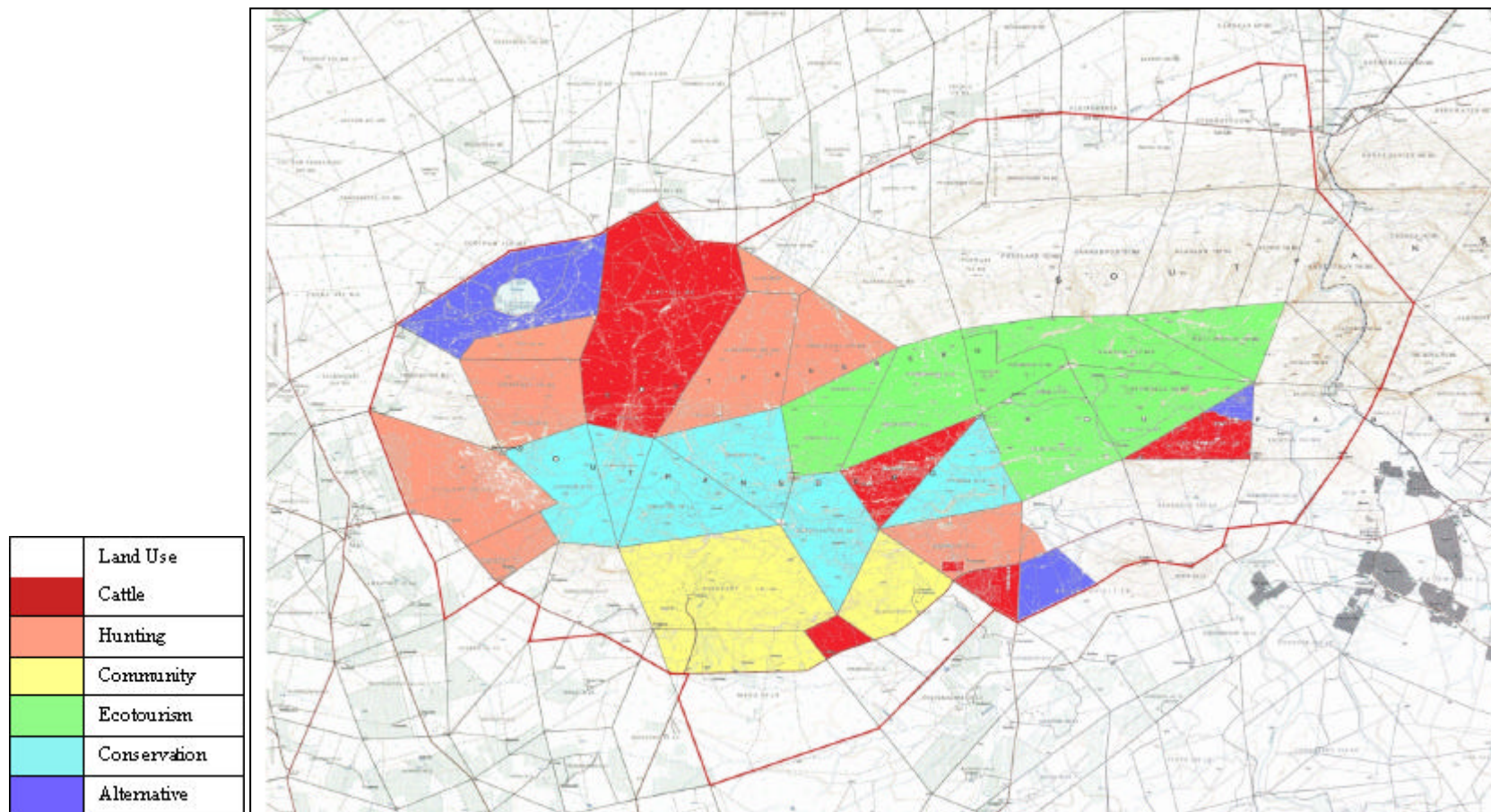


Figure 5.1 Land use in the Soutpansberg Mountains

5.3.1 Land Restitution

In addition to the shift in land utilisation in the Soutpansberg from cattle to game farming, the process of land restitution is also driving change in land ownership and use. Land restitution began after the democratic elections in 1994 in South Africa when the South African parliament passed the Restitution of Land Rights Act (Rosmarin 2008). Under this act individuals and communities that had been forcibly removed from their land due to racially discriminating laws under the Apartheid regime could claim land rights for properties that had been lost (James 2000). The function of land restitution was to redress the past injustices of Apartheid caused by the forcible removals, provide justice to land claimants and aid in the redistribution of wealth from the white population to the majority black population (James 2000). Many of the white owned game farms or ecotourism properties in the study area are under land claim or have previously been subject to claims. The effect of this was noted in the attitudes of some white landowners towards their properties with certain individuals interviewed expressing a lack of interest in their land and its wildlife because it may soon be reclaimed by a black community.

5.3.2 Land use groups

Six main land use groups were identified in the patchwork of private and community lands in the Soutpansberg as below:

1. Game farm owners who use their properties trophy hunting
2. Game farm owners that use their properties for ecotourism
3. Cattle farmers
4. Community farmers
5. Conservationist landowners
6. Landowners that either do not derive their income from wildlife, or farm animals that are not eaten as prey by leopards (i.e. are not financially affected by leopard depredation), these farmers will be known as alternative income farmers from here on.

These groups are divided via both land use type and ethnicity, with Afrikaners involved in cattle farming, conservation or alternative income generation; British South Africans in game hunting, ecotourism or conservation and Venda and Buys communities conducting subsistence livestock farming. There is some overlap between hunting and ecotourism properties within the game farming industry. Although hunting farms specifically involve the use of game species for trophy or food purposes, both hunting and ecotourism farms can be involved in live game capture and sales.

5.3.3 Farms in the study site

Twenty three properties were identified on the study site which are owned by twenty different landowners or land owning communities. Of these properties, five are commercial cattle farms, five are used for game hunting, three are left fallow, another three belong to landowners that are involved in alternative income generation, a further two are part of a local conservancy, two are used for ecotourism purposes and two belong to local communities – one to a Venda communal farming community and the other to the Buys people.

With this background in place, the next section will outline the methodologies employed to examine the perceptions and attitudes of landowners and farmers towards leopards, leopard conservation and human-wildlife conflict in the Soutpansberg Mountains.

5.4 Methodology

5.4.1 Study design and sampling

Qualitative anthropological data was collected on the perceptions of landowners and farmers towards leopards, leopard conservation, human-wildlife conflict and trophy hunting over a period of 18 months in order to discover how these attitudes affect people's actions regarding leopards, whether they chose to hunt them legally or illegally or aid in their conservation.

A qualitative approach was chosen for data collection for two reasons. Firstly, due to the low available sample size of participants in the study area (23 farms), it was decided that qualitative data would be collected and analysed instead of quantitative data. Quantitative data is useful for identifying broad trends in attitudes but in order to identify these trends correctly, large sample sizes are required to achieve statistical significance (Bernard 2006). Qualitative data was therefore chosen as it would not be possible to collect large enough sample sizes of interviews or questionnaires to achieve the appropriate level of statistical power. Secondly, qualitative data was selected as it can be used for obtaining rich socio-cultural information from study participants. These types of data were required to understand the attitudes and perceptions of respondents towards leopards in the complex socio-cultural mixture of communities that make up the Soutpansberg.

Three anthropological techniques were used during this study. These were participant observation, semi-structured interviews and self administered questionnaires. Participants approached in the study were selected to represent the full range of stakeholders present in the Soutpansberg – landowners and farmers, provincial and local government officials, members of the hunting industry and staff from conservation NGOs.

5.4.2 Identifying participants

One of the first challenges when conducting anthropological fieldwork is identifying participants for ethnographic study. Initial participants were identified via the owner of the research station that provided a base for this project. This owner served as a gatekeeper for accessing landowners on the study site, local government officials in Makhado and members of conservation NGOs. The term ‘gatekeeper’ is used to describe a person that provides a means of contact between a researcher and the subjects to be researched (Eklund 2010). This gatekeeper was of exceptional value in providing access to potential participants as he owned land in the Soutpansberg, thus was part of the landowning community. He was also very active in the field of local leopard conservation having acted as the chair of the local leopard conservancy which meant that he was well acquainted with local government officers and members of NGOs involved in wildlife management and conservation.

The gatekeeper provided contact details for other landowners on the study site and where these were not available provided advice on the most appropriate way to contact farmers. Initial contacts with respondents were then made via telephone or exploratory visits where telephone numbers could not be found. Once contact had been made with respondents further participants for the study were recruited via chain referral or ‘snowball sampling.’ Chain referral is a network sampling method that utilises existing informants to locate further participants (Bernard 2006). Commercial hunters known to landowners were often recruited in this way and were useful in providing insights into the hunting industry.

5.4.3 Interaction with participants

5.4.3.1 Participant observation

Once participants had been identified, interaction involved the use of methodologies such as participant observation and formal interviews and questionnaires. Participant observation has been termed as the foundation of cultural anthropology (Bernard 2006). This method involves spending extended periods of time in a community observing the

behaviour, conversations and details of everyday lives of participants (Bernard 2006, Geertz 2000). In order to obtain integration between biological and anthropological fieldwork parts of the study, participant observation was conducted whilst collecting both social and ecological data. For example whilst camera traps were being checked, scat samples were collected or live traps were being set and checked for collaring purposes it was possible to meet with landowners, property managers and farm workers and gather information from them regarding attitudes towards leopards, illegal hunting reports and human-wildlife conflict. Informal interviews were conducted during the process of participant observation whenever the opportunity arose, these occurred during meetings with hunters, government officials from the Department of Environmental Affairs and Tourism (DEAT), NGOs and landowners. Participant observation was also used during any community social events that occurred. All information obtained from participant observation such as direct observation, encounters and conversations were recorded in an ethnographic diary (Sanjek 1990).

Whilst conducting fieldwork, an opportunity presented itself to attend two fora on the conservation and management of leopards. These were the South African Leopard Forum and the regional Soutpansberg-Mapungupwe Leopard Forum. Stakeholders present at these forums included biologists, NGOs, hunting industry members and government representatives. Attendance of these meetings provided information on provincial and national issues surrounding leopard conservation and management.

5.4.3.2 Semi-structured interviews and questionnaires

Semi-structured interviews were used as a more formal method of gathering data after a period of participant observation had been undertaken with respondents. This methodology was utilised in order to expand or clarify information gathered during participant observation. Semi-structured interviews are a widely used research methodology to obtain anthropological data (Bernard 2006, Munn and Drever 1995). With this methodology, the interview topic is chosen in advance but the interviewer is able to follow leads during the interview and change the way questions are asked if necessary. Semi-structured interviews were conducted with government officials and members of the hunting industry. Topics during interviews included the trophy hunting

process, illegal hunting, human-wildlife conflict, livestock management, government structures and leopard conservation and management.

The final phase of data gathering involved a questionnaire survey administered to landowners, farmers and local communities in the Soutpansberg from October to December 2008 to obtain detailed information on land use, game or cattle holdings, stock losses, livestock holding techniques, trophy hunting uptake, illegal hunting and views on leopard conservation. The questionnaire survey was conducted at the end of the survey after 15 months of participant observation with landowners and farmers to ensure a rapport had been built with respondents before questioning and that they were comfortable with both the subject matter and the interviewer.

Twenty landowners were questioned during the survey and included properties of different land use types – game and cattle farmers, eco-tourism operators, conservationists and hunting farm managers. Questionnaires took the form of personal, face to face interviews. Before the interview, the participants were given information about the study and were informed that they would remain anonymous in any information gathered. All interviews were fully transcribed and where given permission were also recorded using an Olympus digital voice recorder (Olympus UK Ltd).

A copy of the questionnaire can be found in Appendix 1. A draft questionnaire was produced before fieldwork began. To ensure the relevancy of its biological and anthropological context, the content was revised before being administered and changes made were informed by biological and anthropological data obtained during the fieldwork process.

5.5 Sampling limitations

As discussed earlier in this chapter, the community in the Soutpansberg is made up of a mixture of ethnic groups and cultures including the black Venda rural population, the Buys community, Afrikaner farmers and British South Africans. Due to the legacy of Apartheid there is little social interaction between different groups and this had a

significant impact on access to certain communities and respondents and limited the breadth of data collected to mainly Afrikaners and English speaking South Africans.

A number of factors contributed to the difficulty of accessing certain ethnic communities. Firstly, the gatekeeper used in this study belongs to the white landowning community; therefore the majority of referrals he made for other study participants via chain referral were to other white landowners, hunters or members of wildlife conservation community. Secondly, being a white person myself may have also affected how I was viewed by some non-white respondents and therefore may have negatively affected their desire to participate in the study. The result of this lack of access to non-white communities in the Soutpansberg means that it was only possible to collect limited data from these communities on levels of human-wildlife conflict, illegal hunting, livestock management and trophy hunting practices. This had the effect of limiting the conclusions on the best way to engage these communities in leopard conservation.

The problem of access to black or mixed race communities did not however have a strong impact upon the central question of this thesis, which was to examine whether trophy hunting acts as an effective conservation tool for leopards in the Soutpansberg. As discussed later in Chapter 6, the Venda or Buys communities do not conduct trophy hunting and there is also very little black employment in or engagement with the commercial hunting industry. Reduced access to these communities did not therefore limit information obtained on the trophy hunting process or affect the analysis of commercial hunting as a conservation tool for leopards.

A pilot study was conducted in 2005 to obtain preliminary data on landowner attitudes towards leopards using questionnaires and semi-structured interviews. During this pilot it was already clear that it would be very difficult to gain access to black and mixed race communities. However, as the study was to focus on trophy hunting it was decided that in order to make data collection and analysis manageable within the scope of an interdisciplinary study in which 60% of the focus was on biological data collection, it would be necessary to direct the bulk of data collection towards the social groups engaged in trophy hunting.

There is therefore a very close proximity between the questions and path of enquiry laid out in the proposal for this study, the progression script and the thesis with the central question focussing specifically on trophy hunting, and an extremely close fit has been made between the original funded proposal and the results of this research.

To conduct a full attitudinal survey of landowning groups towards leopards in the Soutpansberg would require a separate ethnographic study of Venda and Buys communities. In order to do this another pilot study would have had to be conducted to find appropriate Venda and Buys gatekeepers. This would have involved long periods of participant observation and severely limited the time available to collect biological data on leopard ecology. Interdisciplinary research requires that limitations be imposed on the extent of data collection in order to effectively answer research questions. The researcher has to therefore deliberately limit the scope of research in order to focus and undertake all tasks required.

To fully understand all the facets and drivers of leopard conservation in the Soutpansberg, further research is required into the attitudes of the Venda and Buys communities towards leopards, levels of human-leopard conflict, illegal hunting and livestock management but this is outside the scope of this study. As a result of the identification of this research gap, a further study has been set up to examine human-wildlife conflict and attitudes towards leopards in local black communities.

5.6 Data Analysis

Qualitative data from questionnaires, interviews, participant observation and leopard forums were transcribed and coded for topics using NVivo 8 (QSR International Pty Ltd). Coded data was then examined for emergent patterns and was interpreted using schema theory. This method of analysis was chosen because schemas can provide information on the interpretive system behind an individual's goals and actions and facilitate understanding of the reasons why people decide to act a certain way in particular situations (D'Andrade 1992).

5.6.1 Schema theory

Schema theory is an analytical technique that combines anthropological linguistics and cognitive psychology to examine textual data such as ethnographic information, interviews and questionnaires (Bernard 2006). Proponents of schema theory argue that people understand events, tasks and objects in the world through the activation of internalised schemas and comprehend them by instantaneously comparing them to established configurations of features created through earlier experience (Bloch 1991). Interactions with cultural and social environments are active in forming a person's schema of objects and events, therefore interpretative schemas are partly produced by the physical and social environment in which they live (Bernard 2006).

An example of the use of schema analysis can be found in Rye (2000) on human wildlife conflict in Indonesia. Rye (2000) uses schema theory to analyse perceptions of crop raiding between Javanese transmigrant farmers and wild pigs (*Sus barbatus*) in Eastern Sumatra. Rye (2000) found that migrant Javan farmers conceive the wild pigs that threaten their crops as malevolent animals led to crop raid by a 'pig man,' an immortal, mythical creature with the body of a man and a pig's head who commands the wild pigs to enter their gardens of the Javanese farmers and destroy their crops. The 'pig man' is believed by the migrants to be a member of an indigenous Sumatran tribe that live in the forest, the *orang suku* who they believe have the power to turn themselves into pigs.

When analysed, this schema for crop raiding contains a number of socio-cultural components. The transmigrant rice farmers were resettled in Sumatra to address overpopulation on Java. Rainforest land was cleared in Sumatra to set up permanent rice cultivation areas to encourage the farmers to move from Java. The shift of rice cultivation to a new island brought challenges that the migrants had not had to face in Java such as dealing with crop raiding wild animals. In Java, the farmers cultivated rice in a non-forest environment so they did not have the skills or coping mechanisms to deal with crop raiding wild animals. Fear of the forest and the inability to resolve the human-wildlife conflict are shown in the depiction of the pigs as evil or malevolent and the 'pig man' as immortal and powerful.

Rye (2000) argues that the schema of wild pigs enacts several cultural meanings for the transmigrants that include Muslim food taboos, fear of the unknown forest environment and social and moral judgement of the indigenous *orang suku*. The *orang suku* are viewed by the migrants as coarse, rude and spiritually unrefined and the depiction of them as people that can turn into pigs and wreak havoc on their fields emphasises the derogatory way in which they are perceived. Most of the migrants are Muslim and hence view pigs as harmful, polluted and taboo creatures. In describing the *orang suku* as having the ability to become pigs, they are conceiving them in derogatory terms and do so by imposing on them their interpretative schemas of the wild pigs that attack their crops. Rye (2000) also found that the migrant farmers perceive the *orang suku* as being jealous of them and therefore they send the plagues of wild pigs in an attempt to make them leave. To the migrants the *orang suku* are responsible for much of the misery in Sumatra in the form of hostile pig men. Thus through the schema of the 'pig man' the *orang suku* act as scapegoats for their conflict between the Javanese rice farmers and the wild pigs.

As shown above, schemas can provide information on the socio-cultural interpretive system behind an individual's goals and actions and facilitate understanding of the reasons why people act a certain way in particular situations (D'Andrade 1992). Schema analysis was used in this study to provide information on the reasons why people choose to undertake certain actions with regard to leopards such as poaching, legal trophy hunting or joining a leopard conservancy. In this way, schema theory was utilised to understand for example why the majority of cattle farmers choose to poison or shoot leopards as pest species despite the fact that evidence has shown that cattle make up only tiny fraction of leopard diet in the Soutpansberg (Nemangaya 2002, Schwarz and. Fischer 2006, Stuart and Stuart 1993, this study).

5.6.2 Respondent's leopard schema in the Soutpansberg Mountains

In this study respondents' 'leopard schemas' varied according to membership of distinct social groupings in the Soutpansberg. However, certain perceptions of leopards were not confined to these groupings and did show contradictions within and overlap across groups. Respondents' perceptions or attitudes towards leopards were examined across the stakeholder spectrum but this chapter concentrates particularly on the leopard

schemata of landowners or property managers in the Soutpansberg as they come into closest contact with leopards and their behaviours and actions have the most immediate impact on them.

Schemata were used here as an analytical tool to enable the clarification and sorting of peoples' associations and concepts of leopards in the environment and relate them to their socio-cultural and economic positions in Soutpansberg society. Table 5.2 represents the way in which data from participant observation, questionnaires and interviews were sorted into themes that reflect and delineate the values and perceptions of the respondents encountered in this study. This table provides an indication of how qualitative data were analysed in this part of the study and is intended to demonstrate how the perceptions and values towards leopards were sorted in relation to the different land use groups. However, it is indicative of the analytical method only and is not intended to cover the entire range of attitudes of respondents which are covered later in this chapter.

Table 5.1 Respondents' Leopard Schemata

Social Group	Value of the Leopard	Character of the Leopard	The Leopard as a problem animal	Conservation of the leopard
Hunting Game Farmers	"Hunting leopards is financially very lucrative, it's the only way I can afford having this farm."	"Leopards are too cunning."	"If it's a game farm there must be leopards on there, that's the risk you take with a game farm."	"Leopards should be conserved but the way to do it is to give it value."
Ecotourism Operators	"The leopard is an attraction for guests and ourselves."	X	"Tourists see leopards and that is a big advantage, that is why leopards are not considered to be a problem animal."	"If you don't know numbers you should conserve leopards."
Cattle Farmers	"I have used dogs to kill leopards. I used to put up a trap and chain it to a plough, the leopard is caught and runs, The leopard mock charges.... this is the best way to get the adrenalin pumping."	"I do not like leopards, they are dangerous and sly."	"Most of the farmers kill the leopard when it is a problem, catch it with snares, if it is a problem just kill the bloody thing"	"You could never kill all the leopards there are too many."
Conservationist Landowners	"The leopard is the most beautiful cat on earth, it is worth preserving for this."	X	"If cattle are kept in this area then people should just deal with the losses."	"The leopard should be conserved for moral reasons."
Community Farmers	"Leopard fat is used by the sangoma (traditional healer) for policemen in order that people would respect and fear him."	X	"They are not well liked as they kill cattle and goats."	X
Alternative Income Landowners	"There is no economic advantage for me here to have leopards but I would prefer to have them here then to say that there's no more leopards left because I like nature and nature is complex."	X	"Leopards are not a problem – they are part of nature."	"Leopards should be conserved for the future, they are part and parcel of life here."

5.6.3 Ethics

Anthropology ethics guidelines of the Association of Social Anthropologists of the UK and Commonwealth were adhered to throughout the study. A full written information sheet written was given to participants before consent was requested for questionnaire and face to face interviews and written consent was obtained from farmers or landowners before interviews began. All consent forms were retained and participants were asked whether they wished to remain anonymous in any published work. A copy of this form can be found in Appendix 2. Animal ethics approval was obtained from the Life Sciences Ethical Review Panel of Durham University.

5.7 Landowner and farmer perceptions and attitudes towards the leopard

Stakeholders perceive leopards both in terms of their economic and non economic values which include certain financial, aesthetic, ecological and symbolic attributes. Due to real or perceived livestock predation, the leopard is also viewed as an agent of human-wildlife conflict and landowners and farmers that rely on domestic animals for income generation describe certain behaviours of the leopard in terms of negative human characteristics in order to justify leopard persecution. Membership of different economic and socio-cultural groups also affects respondents' attitudes towards leopards as predators of domestic animals and determines their decisions to undertake legal or illegal hunting of these carnivores. In addition landowner and farmer concepts of utilitarianism or protectionism affect views on whether the leopard should be conserved in the area.

As a large carnivore, the leopard is one of the top predators within its ecosystem. Its position as apex predator frequently draws it into conflict with humans due to its protein rich diet, large home range and preference for ungulate prey (Hayward et al. 2006, Treves and Karanth 2003). These factors place the leopard in recurring competition with humans that have similar requirements (Treves and Karanth 2003). Human-wildlife conflict can include attacks on people, domestic livestock or competition for prey (or trophies from recreational hunting) (Knight 2000). Research undertaken on human-carnivore conflicts found that livestock predation is one of the most common causes of conflict between humans and big cats (Sillero-Zubri and Laurenson 2001). This conflict is a major issue for wildlife conservation as livestock predation often leads to negative attitudes and retaliatory killings of large predators by members of affected communities and can result in their extirpation from many areas (Sillero-Zubiri and Laurenson. 2001, Woodroffe et. al. 2006).

Many projects set up to mitigate human-wildlife conflict focus solely on the ecological side of the issue with no input from the social sciences regarding analysis of the human aspect of the conflict (Conforti 2003, Treves et al. 2006). As the attitudes and actions of humans that live with carnivores ultimately determine the course and resolution of human-wildlife conflicts, it is crucial that the human dimension is recognised and

incorporated into management plans (Manfredo and Dayer 2004, Marker et al. 2003, Sillero-Zubiri and Laurenson 2001). Personal values have a particularly important influence on attitudes towards large carnivores therefore understanding the factors that contribute to the formation and maintenance of values is vital to dealing effectively with human-wildlife conflicts and recruiting local stakeholders into carnivore conservation and management (Naughton Treves et al. 2003, Zimmerman et al. 2005). Anthropological data can provide information on the cultural and socio-political context of human-wildlife conflicts and ensure that wildlife management strategies are locally sensitive and effective through being informed by social as well as biological data (Breitmoser 1998, Knight 2000, Treves and Karanth 2003).

The coexistence of differing land uses within a single landscape and membership of landowners to a particular profession or social group are two of the main factors that shape attitudes and perceptions of wildlife in the Soutpansberg. These factors determine whether individual farmers view certain species as economically valuable or as problem animals. This influences wildlife categorisation as domestic, game, wild or pest species and affects landowner behaviour towards these animals accordingly.

Previous quantitative research has found that social identity and occupation in rural communities are powerful predictors of attitudes towards carnivores (Naughton Treves et al. 2003). This may be due to the fact that attitudes towards large predators are established early in life and become further entrenched as individuals are socialised into different professional cultures (Naughton Treves et al. 2003). These attitudes are connected to individuals' lifestyles and once established become deep rooted. Within these social groups or professions, members share a social environment that reinforces their value laden attitudes towards wildlife and fosters a sense of shared values and goals which can lead to the creation of a group subculture and associated world view (Manfredo et al. 2003, Naughton Treves et al. 2003).

Definitions of what constitutes a 'game', 'wild' or 'pest' animal may seem ambiguous to an outsider but form a set of mutual understandings and cultural concepts among members of Soutpansberg society. Game animals are free living, non domesticated animals that are hunted for food or sport. However, in the Soutpansberg this definition is altered by differences in land use. Antelope species that are stocked on a hunting

game farm are considered to be ‘game’ animals that are brought in by landowners for trophy hunting purposes. On a neighbouring ecotourism property these same species are considered to be ‘wild’ animals by tourists that come to view them, despite the fact that they are as highly managed as animals on hunting farms. Landowners’ perceptions and attitudes towards wildlife are further affected by landscape level features such as fencing. The majority of private farms are fenced confining many animals to a single property. This creates a sense of ownership for landowners over species such as bushbuck antelope (*Tragelaphus scriptus*), warthog (*Phacochoerus africanus*) and bush pig (*Potamochoerus larvatus*) which naturally occur in the area and may not need to be purchased at local auctions. However, although there may be a lack of consensus as to what defines animals that are confined to properties due to fencing, species that range beyond artificial, human created boundaries such as leopards, cheetahs, hyenas (*Hyaena brunnea* and *Crocuta crocuta*) and baboons (*Papio ursinus*) are more universally seen as pests.

The patchwork nature of land in the Soutpansberg also means that neighbouring properties often have conflicting land uses. Ecotourism properties and conservation areas are found adjacent to hunting or cattle farms as can be seen in Figure 5.1. This causes disagreements between neighbours over utilisation of species leading to acrimonious relationships that impact upon surrounding human and wildlife communities. During this study a number of instances were noted of conflicting land use between neighbours. One example involves ecotourism landowners that owned a property adjacent to a hunting farm. The hunting farm owner wished to use his neighbour’s ecotourism property to shoot bush pigs in return for the donation of a few giraffe. The ecotourism operators refused the proposal as they felt they would not be able to ensure that their neighbour’s hunting clients would only take a small number of bush pigs. This disagreement led the hunting farm manager to wire up the gate between the properties out of anger therefore trapping their neighbours’ eland (*Taurotragus oryx*) out of their farm. After this event all communication stopped between the neighbours. The relationship between the neighbours of these two properties is particularly important for leopard conservation as on one side of the fence leopards are conserved for ecotourism purposes whilst on the other the hunting manager was identifying the same leopards to be shot in the next trophy hunt. Due to the lack of communication between properties it was not possible to come to an agreement between

neighbours regarding a mutually beneficial solution to their conflicting utilisation of leopards.

Another instance that was noted was of the differing attitudes towards leopard utilisation between a hunting farm manager and his cattle farming neighbour. The hunting manager trophy hunts leopards on his property for economic profit whilst his neighbour poisons them as pest species. Regarding his neighbour's behaviour of poisoning leopards the manger said, "That's not hunting, it's just stupidity, there's no type of thought process, that's an old type of stock farmer's mentality, his parents and his grandparents did that without any regard for the environment."

The existence of adjacent properties with conflicting land uses has both social and biological consequences for the human and wildlife communities of the Soutpansberg. As previously discussed, membership of a social group or profession has been found to be a strong predictor of attitudes towards carnivores (Naughton Treves et al. 2003). Attitudes of members of social groups are reinforced via interaction with others that share the same perceptions towards an issue. However, these attitudes can also be strengthened via interactions with members of another social group that hold conflicting opinions and this can serve to reinforce in-group boundaries (Knight 2000). Utilitarian or protectionist attitudes towards wildlife held by Soutpansberg landowners may therefore be reinforced by interactions with neighbours that hold opposing views as in the previous example.

The biological effect of a multi-use landscape that has adjacent properties with consumptive and non consumptive uses of wildlife means that the home range of free ranging species such as leopards encompasses both types of properties. On a landscape scale leopard populations are being fostered on conservancy land and poached or legally hunted on cattle and hunting farms. This can create a population source of leopards on properties where they are conserved and population sinks where the leopard is hunted or poached (Novaro et al. 2005). The source and sink dynamic may negatively affect the wider population by increasing intraspecific aggression and therefore mortality between incoming adults and territorial males. If mortality from sink areas outweighs the number of leopards coming in from source areas the population will decline (Delibes et al. 2001).

Quantitative research undertaken on human attitudes towards carnivores has shown that a number of different socio-economic variables affect levels of tolerance towards predators such as age, gender, level of education, relative wealth and direct experience with carnivore predation (Conforti et al. 2003, Ericson and Heberlein 2003, Gusset et al. 2008, Kaltenborn 2006, Kellert et al. 1996, Naughton-Treves et al. 2003, Williams et al. 2002, Zimmerman et al. 2005). These studies show that in general older people, females, those with lower education, people working in resource dependent professions such as farming, rural communities, those living within carnivore ranges and individuals affected by economic losses due to carnivores tend to hold more negative attitudes towards these species (Kaczensky et al. 2004). Further studies conducted on the effect of societal change on attitudes towards carnivores over time suggest that increased urbanisation, education and economic prosperity have caused a general shift in public feeling from utilitarian, dominionistic views of wildlife to a more protectionist stance (Manfredo et al. 2003, Williams et al. 2002). This quantitative work on peoples' perceptions towards wildlife is valuable as it can provide a broad overview of public opinion towards carnivores which may then be used to direct further detailed research (Oli 1994).

5.7.1 The status and value of the leopard

The leopard is known to hunters and tourists in South Africa as one of the 'Big Five', a term originally used by big game hunters in Africa to describe the five most dangerous and difficult wild animals to hunt – the lion, the African elephant, the black or white rhino (*Ceratotherium simum*), the buffalo (*Syncerus caffer*) and the leopard. All these species possess an iconic quality due to their size and strength, the potential danger they present in a hunt and their charismatic attraction. South Africa currently has the largest trophy hunting industry in Africa (Lindsey et al. 2007) but millions of people also come to the country as tourists to see the 'Big Five' and capture them on film rather than to hunt them (Sontag 1977).

Leopards in the Soutpansberg are viewed by many landowners very much in terms of their status as one of the 'Big Five.' For some this includes how they can make money from the leopard's iconic position while for others the presence of leopard on their

properties enriches their lives in a non financial way. One landowner who uses his property for conservation and scientific research purposes acknowledged, “The leopard is an iconic animal, it is one of the ‘Big Five’”. Some informants speak frequently of the value of the leopard in utilitarian terms - how it provides economic returns to landowners via consumptive use through trophy hunting or how it provides money for landowners via ecotourism. Others speak in terms of inherent non economic values of the leopard – its beauty, the fact that having leopards on your land adds natural value to the property and contributes to the quality of life. Other respondents are drawn to the symbolic attributes that the leopard represents to them – those of power, courage and dignity, and therefore people in authority among the Venda community use the leopard’s skin or body parts in order to take on those qualities themselves.

Research regarding human perceptions and attitudes towards large carnivores has found that humans associate large predators with a number of different ethical, cultural, economic or ecological values (Breitmoser 1998, Conforti et al. 2003, Gusset et al. 2008, Karlsson and Sjöström 2008, Kellert et al. 1996, Pratt et al. 2004). Quantitative studies have shown that attitudes regarding the value of carnivores range from people with strongly utilitarian orientations that support consumptive human use of wildlife to those with a strongly protectionist outlook that oppose hunting and endorse wildlife protection measures (Zinn et al. 2002). These opposing attitudes towards the value of wildlife are made up of basic beliefs about human relationships with wildlife which form schemata and may be used to predict human attitudes towards hunting, wildlife management activities and responses to wildlife threats (Zinn et. al. 2002). People with strongly utilitarian views towards wildlife primarily value wild animals in terms of their financial returns and utilise them due to their market value via hunting, fishing or ecotourism (Karlsson and Sjöström 2008, Pratt et. al. 2004). Those with a more protectionist stance value the non-financial qualities of carnivores. These include the ecological importance of predators in controlling prey populations and preventing ecological imbalance in the ecosystem, aesthetic values such as beauty and power, the symbolic role of carnivores as a manifestation of wilderness and to some the mere existence of a certain species has value (Breitmoser 1998, Conforti et al. 2003, Kellert et al. 1996).

The appreciation of different wildlife values is driven by socio-economic and cultural factors such as education, ethnicity, income and status as an urban or rural resident (Karlsson and Sjöström 2008, Kaltenborn et al. 2006). Research undertaken on attitudes towards North American carnivores such as the wolf (*Canis lupus*) have found that the majority of urban residents hold a more distant, romantic and protectionist view of large predators in contrast to that of rural groups that traditionally regard them as a threat to livestock or ranched game (Gusset et al. 2008, Kellert et al. 1996, Sillero-Zubri and Laurenson 2001). However, if rural communities and landowners who experience economic losses due to carnivores do not benefit from wildlife, they will not support predator conservation measures (Prins et al. 2000). Kellert et al. (1996) found that farmers in Minnesota held negative attitudes towards a proposed wolf reintroduction as they saw wolves as having little ecological, recreational or ethical value. In such instances where carnivores have no value for the people that live with them, trophy hunting of predators may increase the value of predators and money obtained from hunting may be offset against economic losses due to predation (Sillero-Zubri and Laurenson 2001).

Trophy hunting game farmers

Game farming for hunting purposes involves managing the production of free ranging animals on large, usually enclosed, private land for the purposes of live game sales, trophy hunting (mainly by foreign clients), wildlife meat production and biltong hunting (hunting by local people for sport and meat purposes) (Cousins et al. 2008, van der Waal and Decker 2000). Landowners buy in game for these purposes - usually a range of antelope species which are chosen for their hunting value. Game farming therefore can involve a large outlay of money: some farmed game species are highly expensive (a sable bull can cost as much as £270,000 (<http://www.krugerpark.co.za/krugerpark-times>, retrieved 4th September 2010)). The money spent on game then needs to be recouped via hunting or ecotourism activities. The attitude of game farmers towards wildlife is therefore often heavily inclined towards utilitarian values, they see wildlife as a business and the species present on the farm are viewed in terms of their economic value. This attitude extends also to the leopard. A game farm owner involved in the hunting business stressed the importance of leopard trophy hunts, 'Clients want Big Five hunts...so you have to offer it to them

otherwise they'll go somewhere else. Hunting leopards is financially very lucrative, it's the only way I can afford having this farm." Game farm owners often see leopards purely in these economic terms, indistinguishable from any other wild animals on their land, "The leopards are here, I should be able to utilise them" and "I don't particularly feel that killing a leopard is any worse than killing an impala."

Ecotourism operators

Game farming for ecotourism involves a similar farming model to trophy hunting farms but without the consumptive use of species. Here animals such as giraffe (*Giraffa camelopardalis*), sable, white rhino and plains zebra (*Equus burchellii*) are brought in from wildlife auctions to attract tourists and game on the property are as highly managed here as they are on hunting farms. Landowners engaged in ecotourism have similar utilitarian views to hunting farmers towards the leopard as its presence on their property has economic value as a tourist attraction. However, as ecotourism operators obtain money from tourists seeing live leopards rather than killing them for trophies, the concepts of 'leopard value' held by this group of landowners centres on the experience of seeing a leopard, alone or with tourists, "If we (see them) it is a special occasion" and "The leopard is an attraction for guests and ourselves." These landowners are less positive about killing problem leopards on their land as they have a high tourism value as one of the Big Five. An ecotourism landowner stated, "The leopards are not in such high numbers to make hunting necessary." They show similarity to the attitudes of conservationist landowners in their reluctance to undertake lethal control of problem leopards but differ from this group in that they do not highlight the non-utilitarian benefits of having leopards on their land such as the ecological value of the leopard's role as a top predator. This may be due to the fact that the leopard can prey on valuable game and this may have a negative economic impact on ecotourism operations.

Cattle farmers

Cattle farmers' perceptions of leopards are often coloured by the view of leopards as stock raiders and the value of the leopard is viewed within this context. Due to perceived or real leopard predation on livestock and the inability of local government to deal effectively with problem leopards, cattle farmers often 'take the law into their own hands' and bait leopards with animal carcasses and then poison or shoot them. Many cattle farmers speak of the value of leopard skins that have been illegally poached and then sold onto the black market, "(the government) tries to make it illegal, you can sell leopard skins, there is a big market for them and you can get R3000 - R10,000 for a skin." Others highlight the non financial values of illegally hunting leopards such as the excitement this activity involves, "Farmers shoot leopards on sight, it's a lot of excitement" and "I used to put up a trap and chain it to a plough, the leopard is caught and runs. The leopard mock charges, adrenalin is pumping, it's the best way to get the adrenalin pumping."

Conservationist landowners

Conservationist landowners are a group of landowners who do not allow hunting of wildlife on their properties and are members of a local conservancy that has pledged to conserve leopards. These landowners have other non-agricultural sources of income and often leave their properties fallow as they use their land for personal recreation or scientific research on local flora and fauna. Approximately 40% of these landowners also have small scale ecotourism operations on their properties. Landowners involved in conservation activities are similarly attuned to the status of the leopard as an iconic species as game farmers. One of the most frequently mentioned attributes of the leopard from this set of landowners is its beauty, "The leopard is the most beautiful cat on earth, it is worth preserving for this." However, this viewpoint is not unique to conservationists, game farmers and hunters also praised the physical beauty of the leopard. A game farmer who was known by his neighbours to have illegally hunted leopards on his property said 'Leopards are beautiful' and a local hunter who was active in promoting sustainable hunting in the province but had also illegally shot two leopards said, "I love them because they are beautiful, once I have shot a leopard I like to stroke and pamper it."

The presence of leopards on land owned by conservationists brings non-economic values to the property expressed as an increase in the quality of life and the thrill of knowing that you might walk into such an animal on your land, “Just to know that when you are walking you might be able to see a leopard. Although it happens once in a hundred times but still but it adds value to the quality of life and I think life is about its quality” and “It might be something in our genes, people might be afraid of large predators because when you see a leopard on foot you really get a fright, it doesn't matter who you are, it's like a primitive feeling. It's just nice to know that despite everything there are still large predators like leopards walking around.” These landowners also speak of the non economic natural value that leopards bring to their land, “they are adding natural value to your farm. Someone would rather go where there are leopard that have been naturally there for many years.”

Another valuable attribute that many of these landowners feel leopards possess is the useful ecological service they provide by preying upon other problem species, “Leopards are part of nature, they add value to our properties and they are keeping some problem animals at bay like the baboons.” Baboons are particularly disliked by landowners in this area for crop raiding and eating livestock and game and are often cited as the animal that causes the most human-wildlife conflict in the area, far more so than leopards. Leopards are also thought by some landowners to keep the populations of other predators down, “there are a lot of other things - caracal, jackal - other animals that also kill small game and if you remove leopard the problem might actually increase.” This view was also echoed by landowners with alternate incomes who also highlighted the role of the leopard in reducing populations of problem animals like baboons, “When I was younger there were very few baboons and in winter now when you drive from Waterpoort to the N1 if you really start counting you see maybe 100-200 baboons coming from the mountain where they sleep down below. They are there because we started planting stuff that wasn't here and we undid that balance and if you start killing off the leopards and the natural predators then it's even worse.”

Community farmers

Community landowners in the Soutpansberg are normally of Venda ethnic origin or are members of the mixed race Buys farming community. These communities live on

shared land and communally farm livestock such as cattle, sheep and goats. Leopards were cited by all respondents interviewed as problem animals implicated in livestock killings, “They are not well liked as they kill cattle and goats.”

Due to lack of infrastructure, capacity and a mistrust of government regulations and trophy hunting companies, neither trophy hunting nor ecotourism is conducted on communal lands. Leopards therefore hold no financial value to community farmers and are often snared or poisoned as a result. One community leader mentioned that they had contacted the local wildlife authority to help catch a leopard thought to be taking livestock, “We spoke to Nature Conservation who put up a pig here but the leopard did not eat it, we hoped it would so we could poison the leopard.”

Despite the universal view of leopards on community land as problem animals with no financial value, leopards are valued by local communities for certain symbolic qualities that they represent to them. The Venda people for example use leopard skins in ceremonial dress or consume leopard meat and fat in traditional African medicine to enable them to absorb the leopard’s power and strength. A woman from the Ts’wana tribe who assists in running a local community project spoke about the different uses of the leopard, “leopard fat is used by chiefs to lend them dignity” and “The heart is also eaten before an address is given in front of many villages and is mixed with herbs.” She went on to speak of the ceremonial utilization of leopard skins:

“Leopard skins are worn by chiefs of many tribes for their inauguration. The prospective chief used to go out and hunt alone to get its skin. As the leopard is very difficult to catch it is a test for the chief to go out and kill the leopard. A whole skin is needed for the ceremony. Leopards are very hard to catch which is why they are a special symbol for the chief. They don’t use guns but spears to catch them and the leopard might kill them instead so that’s the danger.”

Other figures in authority also use leopard parts for similar reasons “leopard fat is used by the sangoma (traditional healer) for policemen in order that people would respect and fear him.”

There is some ambiguity in the way that community landowners view the value of the leopard. As a livestock killer it holds no economic value and must be destroyed but it is also valued non-financially as a symbol of dignity and power. Ambiguity between positive and negative perceptions of leopards is most pronounced in community farmers with members of other landowning groups displaying a more consistent attitude towards the value of the leopard on their property.

5.7.2 The character of the leopard

Some animals involved in human-wildlife conflicts are viewed as pest species by those affected and research into the anthropological dimension of these conflicts has shown that certain species are often blamed out of proportion for the actual damage that they cause (Knight 2000, Naughton Treves 1997). These species may serve as ‘scapegoats’ for human society and such discourses need to be examined within their wider social context taking into account the cultural symbolism of the animals involved (Knight 2000). Pestilence discourses also serve to characterise the animals involved as unnatural and something that needs to be removed (Knight 2000). Studies undertaken on attitudes towards ‘pest’ species have found evidence of these pestilence discourses. For example, during the eighteenth and nineteenth centuries North Americans of European origin labelled animals such as the wolf, rattlesnake and coyote as murderers, vermin or gangsters and their elimination was seen as a sign of progress. In Europe lynx have been described as ferocious and cunning by rural residents (Breitmoser 1998). In her assessment of crop damage by wildlife and livestock near Kibale National Park in Uganda, Naughton-Treves (1997) found that animals implicated in human-wildlife conflicts were described in negative terms, baboons were seen as crafty, malicious and a menace to women and children, chimpanzees were portrayed as rapists or thieves and elephants were greatly feared. Portraying pestilence as a crime implies moral judgement upon the animals that are involved and makes animal control a question of moral imperative (Knight 2000).

Hunting game and cattle farmers

The projection of certain negative ‘personality traits’ onto leopards was part of some farmers’ leopard schemas. Game farmers that hunt leopards for the trophy industry spoke of them as being “too cunning” whilst cattle farmers depicted them as “dangerous and sly.” In this way landowners highlighted certain behavioural characteristics of leopards such as their elusiveness and the consequential difficulty of hunting them, and represent leopards as possessing negative human qualities. This suggests that game farmers and cattle farmers feel some kind of moral censure towards leopards. One game farmer went further and justified his view that leopards did not need to be conserved because “There are enough leopards around and they are clever enough to survive on their own.” This attitude was echoed by another game farmer, “Leopards would be killed out but they are too cunning.” These respondents seem to rationalize their continued hunting of leopards by negatively characterising them as clever and cunning and thus providing themselves with a moral rationale for exploiting them.

However, one hunter interviewed held more positive attitudes towards what he felt to be ‘the leopard’s personality.’ This hunter said that he saw hunting as a learning process and that he valued the information about animals and the environment that it brought rather than just the excitement of the kill. During his interview he stated, “I have respect for their hunting methods, they are fastidious, they remove the hair from their kill before eating it. They have great strength and are clean animals.” Another local hunter who said he only hunted antelope for meat took the comparison of leopards to humans even further and said, “They are more like humans as they eat meat, so we don’t kill them.”

Conservationist landowners and ecotourism operators

Conservationist landowners and ecotourism operators did not show the same tendency to represent leopards as possessing negative human qualities. They do not fear leopards as they saw them as not posing a physical threat to humans, “The leopard is not a risk to humans, there are no records of leopards killing people,” and “We do not see it as a threat.” One respondent who uses his land purely for personal recreation purposes and is not involved in hunting said that leopards “are residents with equal rights,” therefore

elevating the status of leopards on the property to that of himself, an animal that has the same rights as a human being.

5.7.3 The leopard as a problem animal

The leopard is often seen as a problem animal for game and cattle farmers whose livelihoods depend on the income they derive from farmed game or livestock. These farmers are apt to view the leopard as a pest that takes their animals as prey items but provides no income to the landowner in return. A highly negative attitude towards leopards is particularly marked in cattle farmers who are the social group most prone to poaching leopards. Game farmers on the other hand tend to show more tolerance to losses caused by leopard predation. A marked division is shown in attitudes towards leopards as problem animals between hunting game farm owners and ecotourism operators. Whilst both groups show some levels of tolerance towards leopard predation of game, ecotourism operators chose not to engage in leopard trophy hunting to recoup any game losses due to the income they derive from tourists viewing live leopards.

Hunting game farmers

Game farmers that run hunting operations display ambivalent attitudes towards real or perceived leopard predation. On one hand they are very aware of any game losses that they attribute to leopard predation, “There were plenty of waterbuck here, now there are not so many,” and “Leopard numbers are increasing, they were not a problem before, now we are losing game.” On the other hand they frequently seem to accept real or perceived losses to leopards as part of their chosen profession, “If it’s a game farm there must be leopards on there, that’s the risk you take with a game farm,” and “I think (game farmers) just have to roll with those punches, it’s part of the industry.” However despite this acceptance of game losses to leopards some game farm owners with hunting farms see trophy hunting leopards as a moral act to redress the balance between themselves and the leopard, “What they take, we take back, he has to pay in kind.”

These attitudes may be exaggerated by the government’s view on game farmers’ rights regarding game losses due to carnivore predation. Under current regulations game

farmers are not allowed to destroy predators that may have taken their game. The approach of the government is that game farmers are raising animals such as antelope that are predators' natural prey items and therefore losses must be accepted. Another factor that contributes to game farmers attitude towards losses is the difficulty of accurately ascribing game losses to leopards. Game are spread across a property and often obscured from view by their habitat, so any losses to predation are not readily witnessed. This is compounded by the fact that game species are also hard to count and many landowners do not know the number of each species on their property, therefore losses may not be noticed especially as leopards cache their kills in trees, caves or under bushes.

The recent changes in land use in the Soutpansberg from cattle farming to game farming have helped foster a more tolerant attitude to leopards. As one game farmer noted "There is more tolerance now towards leopards". However, this may not be because attitudes towards leopards have changed throughout the entire population in the area but rather that social groups such as cattle farmers who are well known for persecuting leopards now exist in much smaller numbers.

Ecotourism operators

Ecotourism operators that run game farms are also very aware of real or perceived game losses to leopards, "Leopard predation has caused a reduction in the wildebeest population no young survive because of the leopards," and "Leopards also antagonise sable and have taken out most of the sable." In some instances ecotourism operators sustain heavy losses of expensive game due to carnivore predation. Sable for example are very expensive antelope due to their rarity and one game farm owner explained how she had to replace a whole herd of sable that had been killed by predators. Despite losses these landowners do not see game predation as enough of a problem to turn to trophy hunting leopards in order to make up for the financial impact. This may be due to the fact that ecotourism operators rely on income from tourists who come to see live leopards due to their Big Five status. They thus have little incentive to hunt them as trophy animals and every reason to accept some level of game loss, "We leave (game losses) to nature, it is not necessary (to hunt leopards). We would only do it if they increased," and "Tourists see leopards and that is a big advantage, that is why leopards

are not considered to be a problem animal. I see the leopard as an economic resource. It is part of what we are selling, we sell two of the Big Five. I don't mind losses because of this.” There is some indication however, that if leopards became more of a problem on their land due to an increase in leopard numbers or changes in land use, their reactions to game losses might also change, “If we had so many (leopards) it might be different, if they were a real problem,” and “I am not worried about game losses as I don't sell much game. If I did more captures it would be a problem.”

Cattle farmers

Cattle farmers in the Soutpansberg show the most marked negative perceptions towards leopards as problem animals. All cattle farmers interviewed stated they had lost calves to leopards, “I've had a lot of trouble with leopards.” All were very clear in describing how they dealt with these losses, “Most of the farmers kill the leopard when it is a problem, catch it with snares, if it is a problem just kill the bloody thing.” The detail with which some cattle farmers illustrated their killing methods during their interviews demonstrates the strength of feeling they have against leopards as pest species, “With a gin trap the leopard can turn its leg and take its own leg off and walk without it. Let me tell you how to kill them. ”

Cattle farmers are a quite distinct social group in the Soutpansberg, many of them are older farmers who have lived in the area for generations and support and act on the idea that if an animal gives them a problem they will destroy it. These landowners display a type of ‘pioneer mentality’ towards nature and wild animals and are known in the region collectively as ‘Boers,’ a name which refers to the first Afrikaner farmers that settled in South Africa. For them nature is something that has to be fought against and overcome in order to earn a living. one farmer said, “I am trying to make a living and have to fight animals.” Many perceive that losses to wild animals could destroy their source of income, “Older generation farmers will pay anything to kill a leopard, if there are no calves how can they carry on?” This strength of feeling against the leopard as a problem animal is in part to do with membership of this distinct social group whose negative attitudes towards wild animals have been handed down for generations and are often very ingrained. One cattle farmer related a story in detail regarding a leopard attack on some donkeys that his grandfather and uncles had experienced in 1916. He

said that his uncles “wouldn’t take any nonsense” from the leopard at that time. Another cattle farmer boasted that 40 leopards had been shot by him and his father since 1947.

As previously mentioned, research into the quantitative effects of age and status on perceptions of carnivores and human-wildlife conflict has shown that respondents who are older and rely on livestock as an income resource show more negative perceptions towards predators. The age of these farmers, their inherited profession and membership of this socio-economic group may partly explain their views of leopards. However, constructions of leopards as problem animals may not be entirely attributed to these factors but may also relate to cattle farmers’ dim view of the role of the government’s failure to protect cattle against livestock predation. Some landowners said that they did not look to government help in dealing with problem animals but dealt with them alone, “Yes, if you are a farmer with a leopard, you have to deal with it. I have never run to the government about it.”

The law governing cattle farmers dealing with problem leopards in Limpopo Province is currently ineffective and unenforceable. If a cattle farmer suspects that they have a problem animal and have supporting evidence, such as a kill, they are supposed to call a local government officer who will send out a team to investigate. If the investigators find a problem animal, they will either try and catch it and move it to another location or the farmer will be given a destruction permit which allows him or her to shoot the animal. The weakness of this system is caused by a shortage of staff in the district offices; it can take weeks for an investigation team to check a property. The potential time lapse means that when investigators finally arrive at a property, any animal carcasses which could be used as evidence of leopard predation will have disappeared and the leopard may have killed again. This issue was highlighted by a property manager who used to be involved in the cattle business, “If you have a problem leopard and you are a farmer it’s so difficult to get a permit to have it hunted legally which should at least cover some of your losses, by the time you get the permit that same leopard has either left or has done so much damage and that’s why some farmers resort to trapping and poisoning and just keeping quiet about it.” An alternate means for cattle farmers to deal with problem leopards is to shoot the livestock killer and then report it to a local police within 48 hours, providing evidence of livestock losses. Police stations

often lose such information and it is not passed on to the local government office where it is required for compiling statistics on animals that cause damage.

For these reasons cattle farmers decide it is best to deal with leopard predation alone and in the quickest and often the most brutal way. One cattle farmer who was very open about the way in which he illegally killed leopards said, “I could shoot five leopards per year. I try to shoot them but if the damage is too big I use poison. It is against the law but I don't compromise with losses.” Some cattle farmers resort to using poison such as strychnine or Temic to kill leopards as the quickest way of dealing with them. This illegal and harmful practice causes a build up of poison in the food chain which has been linked to the deaths of other endangered animals such as vultures which consume the carcasses of poisoned cows left out for bait (Koenig 2006).

Many human-wildlife conflicts can also be understood as people-state conflicts, in which regulatory procedures for dealing with carnivore conflicts are poorly managed, non-transparent or corrupt leaving those affected by real or perceived losses to carnivores with little scope to redress damage to livestock or game via the state (Knight 2000). Previous studies have found that solutions to human-wildlife conflicts such as compensation schemes that are overly complex and bureaucratic can discourage use by those that may benefit from them (Karanth and Madhusudan 2002, Mishra 1997, Rodriguez 2008). Kellert et al. (1996) found that regulatory procedures regarding human-carnivore conflicts with bears, wolves and mountain lions that are perceived to be economically or personally threatening are often ignored or undermined by stakeholders. A study undertaken by Rodriguez (2008) on the perceptions and attitudes of a Maasai community regarding a wildlife-damage compensation scheme and the predators that prey on their livestock found that local people held misconceptions about the scheme due to its lack of transparency and understanding of the project. As the scheme provided compensation for wildlife damage, people perceived that the organisers of the scheme owned and took responsibility for the damage causing carnivores and this led to increased negative attitudes towards both the scheme and the predators.

The reason why cattle farmers in the Soutpansberg are honest in talking about poaching leopards is partly because local law enforcement for poaching is so disorganised and

unenforced. It is impossible for law enforcement officers to know if a cattle farmer has killed a leopard on his or her property and quietly buried it. Many landowners feel it is their legal right to protect themselves against stock losses “I shot a leopard that took a calf, I have a constitutional right to kill them, Nature Conservation threatens people but they should pay for the losses if they want to save the leopard.”

Certain quantitative studies on attitudes towards carnivores have found that experiencing a lack of control over one’s life and a feeling of not being able to influence policies about resource management, or even comprehend them, is an important factor in understanding rural perceptions of predators (Bjerke et al. 2000, Kleiven et al. 2004). Perceived lack of power over one’s environment is termed an external locus of control, “Power is being exerted at different levels, and institutions function in ways that are more or less comprehensible to the public. Perceived lack of control over one’s life and the functioning of politics and institutions is....an important aspect of the large carnivore debate. ...Some people experience substantial economic losses, the general feeling of not being able to influence policies about resource managementor even understand them can contribute to antipathy and opposition” (Kleiven et al. 2004). Researchers have found a positive association between an external locus of control and negative attitudes to large carnivores among people that already experience substantial economic losses to carnivores (Bjerke et al. 2000). This may be another reason for such negative perceptions of leopards among cattle farmers in the Soutpansberg, who feel they have so little help from the government over losses that they are impelled to deal with predator problems alone.

Another reason why cattle farmers poach leopards is that they may perceive them to be more of a threat to their livestock than they actually are. Research on leopard diets in Africa has shown that cattle make up a very small percentage of prey intake, even if part of the leopards’ home range extends across a cattle farm. For example, from her study of leopard ecology in Kenya, Mizutani (1999) found that leopards living on a cattle ranch in Laikipia District live at relatively high densities but have less of an impact on livestock than might be expected. Studies conducted on the diets of leopards in South Africa have shown that cattle only make up 0 - 5% of their diets (Nemangaya 2002, Ott et al. 2006, Schwarz 2003, Stuart and Stuart 1993, this study). Previous research on human perceptions of wildlife damage has also shown that people often tend to blame

certain species for taking crops or livestock out of proportion to the actual damage (Conforti et al. 2003, Gusset et al. 2008, Knight 2000, Marker et al. 2003, Mishra 1997, Oli 1994, Naughton Treves 1997, Sillero-Zubri and Laurenson 2001). Inflated perceptions of risk from carnivore predation often outweigh the reality of actual economic damage sustained and drive retaliatory behaviour (Knight 2000, Naughton Treves et al. 2003). These perceptions may relate to the highly charged beliefs associated with large carnivores that have the ability to inflict damage that can have severe emotional, financial and political consequences on farmers (Kellert et al. 1996, Treves et al. 2006). Such associations are shaped by catastrophic or costly events rather than smaller scale losses (Treves et al. 2006). Assessments of risk are also increased by an individual's socio-economic position within a community, their ability to cope with wildlife damage, conflicts with the state over resource management and institutional constraints on coping strategies (Knight 2000, Naughton Treves 1997). In addition large animals such as leopards may be more conspicuous than smaller predators like jackals so therefore receive a larger share of the blame for livestock depredation (Knight 2000). A property manager of a local salt mine in the Soutpansberg raised this possibility when he said, "Caracal and jackal can also be a problem with livestock, they take newborn calves and leopards are often blamed for the livestock losses caused by these species."

Cattle farmers are one of the most contradictory groups in their perceptions and attitudes towards leopards. One retired cattle farmer who had spent much of his life trapping and shooting leopards as livestock killers emphasised his dislike of leopards yet stated at the end of his interview, "I don't complain about them, they are something that happens naturally, and is there, people accept that, I don't feel they have to be removed." Another cattle farmer also said, "I am bunny hugger, I'm a tree hugger, I'm a dolphin hugger, I am an everything hugger unless something gives me a problem."

A similar ambivalence towards carnivores was found by Knight (2000) in his study of attitudes towards bears in rural Japan. Here people showed mixed feelings in their perceptions of bears which included fear, hatred, admiration and affection. Negative emotions stemmed from historical folklore depictions of bears as malevolent demons that were implicated in human attacks. However, as bears became more scarce due to persecution and habitat loss, attitudes towards this species have taken on a counter

perspective through which the bear has come to be viewed as a helpless victim due to its physical displacement from the forests and subsequent diminished status as a threat.

Community Farmers

All community farmers interviewed saw leopards as pest species due to real or perceived predation of livestock. The headman of a local village in the Machabeng area of the Soutpansberg stated, “Leopards are a big problem here. They eat about twenty calves per year,” and a leader of a community that farms property at the foot of the mountain range was also able to quantify the amount of livestock lost to leopards two years previously, “Six calves were lost to leopards in 2007.” In addition to preying on calves, leopards are also implicated in taking goats from community farms, “Leopards come down from the mountain and catch goats.”

As mentioned previously, cattle hold high cultural value in Venda society due to the use of cattle in the institution of bridewealth in which livestock are used to pay for wives. The loss of cattle therefore will not solely have an economic impact on a Venda community but will also have cultural implications by affecting the ties that bind the community through marriage as once the *lobola* (brideprice) is paid in the form of cattle to the bride’s family, the person who paid the price is then responsible for the welfare of the bride. Bridewealth creates a debt that must be repaid by a marriage which will return the cattle to the family that originally paid them (Kuper 1982). If the cattle are lost through predation this may leave the wife with an unpaid debt to the family in which she marries into.

One of the reasons that livestock predation may be such a problem in community farm areas is that little or no anti-predator livestock management techniques are used to protect domestic animals from carnivore predation. One community leader stated that cattle are left to graze in the mountains alone without human supervision. Livestock husbandry techniques such as kraaling (enclosing cattle in at night in predator proof buildings), or using donkeys or dogs for protection is also not practised. The head woman of a local community conveyed her frustration at these livestock losses when asked about problems with leopards in her area, “Leopards are a big problem with livestock especially on the mountains, people are scared of leopards but don’t know

what to do as the leopard comes at night and takes the live stock again and again,” and, “We don’t know what to do about the leopards.”

Studies into the effect of livestock husbandry techniques on carnivore predation have shown that simple livestock management strategies such as grazing animals in open habitat, accompanying herds with human herders and livestock guarding dogs and kraaling livestock in strong bomas at night can reduce losses of domestic animals to predators (Ogada et al. 2003, Woodroffe et al. 2007).

As discussed earlier in this chapter, the majority of the rural black population are women between the ages of 15 and 65 due to the fact that many men are involved in migrant labour and therefore work away from their farming communities (Lahiff et al. 2006). This may partly explain why herds of cattle are left to graze on the mountains with no human supervision as there are not enough community members to look after them and protect them from predation.

Conservationist landowners

Conservationist landowners were one of the social groups that did not view leopards as problem animals but rather saw leopard predation as something that is preventable by proper management of game or livestock. A landowner who is very active in the field of leopard conservation stated, “Farmers that lose a lot of cattle or calves are just not trying to protect their calves, they just don’t care about leopards or if leopards had a value for them they would have done something. I think it’s not always that they don’t know, they just grow up like that – their fathers shot leopards on sight, it’s a lot of excitement and it’s something that one can change with education.” Another landowner who is a member of the local leopard conservancy said of his neighbours, “The neighbours are encouraging nyalas, they are pudding for leopards, stupid animals.” In this statement he was referring to the fact that his neighbours were game farming with antelope that are known to be vulnerable to predation by carnivores.

The trend to have antelope species on game farms that are prone to predation due to their inexperience of living in mountainous habitats and consequent lack of anti-predator skills was apparent on other game farms. One ecotourism game farmer noted

that her wildebeest calves never survived to live to adulthood. The manager of her property maintained that wildebeest females are not suited to taking care of their young in mountainous habitat where they tend to abandon them as soon as they are born.

Conservationist landowners showed a great tolerance to personal losses caused by leopards and believed that other landowners should also accept cattle or game losses from carnivore predation, 'If cattle are kept in this area then people should just deal with the losses, it's part of a conservancy.' One landowner mentioned that he had lost two dogs to leopards but this did not affect his positive way of viewing leopards on his property, 'Two of my dogs were killed by leopards over a period of 12 years, around the house area at night. This didn't change how I felt about having leopards on my property though.'

All respondents in this group are members of a local leopard conservancy group that has agreed not to hunt leopards in order to protect them. Their reasons for not wishing to hunt leopards were often very personal and emotionally driven, 'It's not a rational feeling it's just that I would feel guilty if I allowed someone to shoot a leopard on my property. I just won't feel good about it. It's not worth the money I would get out of it, and 'It is emotionally hard to deal with the idea of leopard hunting.' However, although these landowners do not hunt leopards themselves for profit or in order to get rid of a damage causing animal, there was some level of support for the hunting of problem leopards on community lands in order to provide the poorer community farmers with compensation for livestock losses, 'In South Africa (the leopard) could generate income for communities. If they could give concessions to hunting in tribal areas with it staying in those local areas I could morally accept it. Leopards are especially a problem in subsistence farming areas.'

Landowners with alternative income sources

Landowners with alternative income sources did not view the leopard as a problem animal on their properties. Respondents in this group utilise their properties in highly diverse ways – buffalo breeding, salt mining and traditional healing. A property manager of a traditional healing centre explained, 'Leopards are not a problem for us or sangomas (traditional healers). We don't kill problem animals.' As leopards have no

negative economic impact on these income sources (buffalo calves are too big for leopards to hunt) members of this group tended to view leopards as an intrinsic part of nature, “Leopards are not a problem – they are part of nature,” and “Leopards are part of nature, part and parcel of living and working here. Animals are part of the bush” This view is also held by landowners that keep their properties for conservation purposes. For one conservationist landowner the leopard is “part of the heritage,” a valuable animal that is part of South African’s natural inheritance and should be conserved.

However, landowners with alternative income sources were willing to accept hunting or capture and translocation of leopards on their own property or that of a friend or relative if they suddenly became a problem, “if it were a problem animal I would give permission,” and “I am not pro-hunting hunting but if a calf was caught at a relative’s farm I might support it being darted and taken to another place.”

5.7.4 Leopard population status

There was a consensus amongst almost all respondents in this survey that leopard population numbers in the Soutpansberg are either increasing or are particularly high in the area. One game farmer said, “There’s probably loads more leopards on private game ranches than in all the game parks.” Conservationist landowners also perceive an increase in leopard numbers in the area, “Leopard numbers are higher now than say in 1940 and 1950 because people were farming here and they tried to exterminate them and there was also very little game,” and some view the Soutpansberg as having the largest mountain leopard population in the whole country, “There are lots of leopards on the mountain, the Soutpansberg has more leopards than any other mountain in South Africa.” Certain cattle farmers use this perceived increase in leopard density to justify hunting of leopards, “You could never kill all the leopards there are too many,” and one was so sure of the high numbers of leopards in the area that he said “I could kill 200-300 leopards per year.”

As shown in Chapter 3, the Soutpansberg Mountains are home to a high density of leopards (19 per 100km²) therefore stakeholders’ perceptions of leopard numbers being particularly high in the area are correct. However, as already discussed here and in

Chapter 3, the high numbers of leopards in the Soutpansberg may act as a source for sink populations beneath the mountains where there is more human activity. Therefore, although there may be comparatively high number of leopards here, if the source-sink dynamic goes unchecked, the population may be under threat from a continual population drain from leopards that are drawn into attractive sinks beneath the mountains and killed.

Members of these different groups of stakeholders view the high density of leopards in different ways. For conservationist landowners a greater population of leopards in the Soutpansberg provides an opportunity to bring in money to the region via ecotourism as an alternative to trophy hunting, “The Soutpansberg has a high leopard population and we can sell this area as a leopard destination.” Game and cattle farmers however, are less positive, perceiving an increase in leopard numbers to mean more game and livestock losses, “Leopard numbers are increasing, there is more game, more to eat, they take out my game but I can cope with them,” and “Leopard numbers are increasing, they were not a problem before, now we are losing game.”

5.7.5 Views on conservation of the leopard in the Soutpansberg Mountains

Views on the conservation of the leopard in the Soutpansberg mountains are mixed. Few of the people interviewed felt that the leopard is endangered in the area and only one landowner expressed concern that the leopard might be in danger of extinction in the long term, “I think we still have a chance to protect leopard, to keep this valuable resource in our area but we are running out of time.”

Although many respondents did not believe the leopard to be endangered in the Soutpansberg, only a few game farmers disagreed in principal with the idea of conserving the leopard. One game farmer used the fact that he believes there is a high population of leopards in the area as justification not to conserve them, “Leopards should not be conserved in South Africa. There are enough leopards around and they are clever enough to survive on their own.” Another cited the nature of the leopard as a reason why they would never die out, “they are too cunning.” Landowners from most

other groups agreed that leopards should be conserved in South Africa, “The leopard should be conserved for moral reasons”, “Leopards should be conserved without a doubt, plus we have the habitat and prey in South Africa for this conservation, even though we have Kruger Park we are so behind its shocking.” Even a retired cattle farmer who had stated earlier on in his interview that he did not like leopards and had killed many in the past supported the idea of leopard conservation, “Yes, they should be conserved, they shouldn't be removed from nature, they are here today but tomorrow they might not be.” Some people made no distinction between leopards and other animals in the context of their value for conservation action, “Leopards should be conserved as with any animal, it doesn't matter if it is a leopard, there should be a map to ensure they are there for the next generation” and “There are no animals that I think should not be conserved except may be rats and mice.”

One of the largest conservation problems facing the leopard in this area is that the provincial government does not know how many leopards there are in Limpopo Province yet periodically motivates national government and CITES for increases in the annual number of trophy hunting permits, despite the heavy illegal hunting and poaching pressure on the leopard. For trophy hunting quotas to be sustainable and biologically sound they must be based on accurate field data to ensure that the leopard is not being over-harvested (Spong et al. 2000). This issue was highlighted by the manager of an ecotourism property, ““If you don't know numbers you should conserve leopards, if you know you have loads then they could issue more permits. You need to know the numbers, you can't play God. The government do not know their numbers.”

During interviews certain respondents gave suggestions on the best way to conserve leopards and despite the differences in their professions, ages or backgrounds the solutions were almost identical – the only way to conserve the leopard in the Soutpansberg is to give it economic value. Game farmers stated, “If they have no value they will be destroyed, you need to put a value on them, the farmer will kill them for nothing. If they profit from leopards farmers will look after them. If you get 1 permit per year to hunt leopards you will protect them” and “Leopards should be conserved but the way to do it is to give it value.” Conservationist landowners also acknowledged this point, “(Hunting) is a way of utilising a resource and it brings in foreign currency and creates jobs. If people cannot hunt leopard it will have no value for some people.” It is

clear therefore that many residents in the Soutpansberg are willing to coexist with leopards if they have an economic value for them.

5.8 Discussion

In this study, respondents' attitudes towards leopards, leopard conservation and human-wildlife conflict vary according to their membership of different economic and socio-cultural groups in the Soutpansberg. These social and land use groups determine whether landowners or farmers view leopards as economically valuable, a pest that needs to be killed or a symbol of nature that should be conserved. Previous research has also found landowner attitudes to be closely linked to property use and farmer reliance on land for economic income (Daley et al. 2004). Daley et al. (2004) in their examination of attitudes towards the northern bobwhite (*Colinus virginianus*) in North Carolina found that landowners that depended on their properties for direct income such as agriculture were less likely to consider the aesthetic or non-financial values of wildlife than those that had alternative income sources.

One of the main factors that affects whether landowners view leopards positively and accept livestock or game losses caused by leopards is the economic value that they hold for them. As shown in this chapter, hunting game farm owners and ecotourism operators both state that they do not see the leopard as a problem animal even if it predares upon their game because they obtain money from tourists coming to photograph or shoot it. Alternative income landowners gain no money from leopards on their properties but also experience no economic losses from them therefore they view them as part of nature with an important ecological role to play. Cattle and community farmers on the other hand see the leopard as a pest due to real or perceived livestock losses and as shown later in Chapter 7 are the land use groups most frequently involved in illegal leopard hunting and poaching.

Other studies have also found a relationship between positive perceptions of carnivores and their economic value to landowners. Lindsey et al. (2005) conducted research into attitudes of ranchers towards six species of carnivores on private land - black backed jackals (*Canis mesomelas*), cheetahs, leopards, lions, spotted hyaenas and wild dogs

(*Lycaon pictus*) in South Africa. The researchers found that of the six species, leopards are most popular among ranchers due to the economic value they hold through ecotourism and hunting (Lindsey et al. 2005). As has been found in the current study, land use type also impacted upon the ways landowners viewed carnivores. Ranchers belonging to conservancies and eco-tourism operators were found to hold more positive attitudes to carnivores than those involved with livestock farming (Lindsey et al. 2005).

Human-wildlife conflict is a problem between leopards and farmers in the Soutpansberg, with cattle and community farmers most affected. This conflict is a serious issue for leopards as livestock losses have led to both negative attitudes and retaliatory killings. Lack of government capacity to deal with instances of human-wildlife conflict have exacerbated the problem with many farmers choosing to deal with damage causing leopards by themselves, often with illegal methods.

There are two main ways in which this situation could be improved. Firstly, livestock management techniques need to be improved. These include grazing animals in open habitat, kraaling calves in at night and using livestock guarding dogs. All these methods have been found to help reduce losses of domestic animals to predators (Ogada et. al. 2003, Woodroffe et al. 2006). The second way of reducing illegal leopard hunting and improving attitudes towards them was suggested by the landowners themselves. Almost all respondents in this study despite their land use group said that the best way to conserve leopards was to give it economic value. This would involve improving economic outcomes from trophy hunting of leopards and allow regulated commercial hunting of problem leopards on cattle and community farms.

6: The culture and politics of trophy hunting

6.1 Introduction

Trophy hunting has the potential to be used as a conservation tool if the revenue obtained from hunting can be used to offset the costs of conflict between humans and predators, thus improving tolerance towards carnivores and providing an incentive to conserve wildlife habitats (Leader-Williams and Hutton 2005).

However, for a wildlife management strategy to be effective, it needs to be socially and culturally compatible within the context in which it is applied (Knight 2000). To examine the potential for trophy hunting as a conservation tool for leopards, it is important therefore to understand the cultural, social and political framework in which the industry operates and how different stakeholders relate to trophy hunting in South Africa.

An examination of hunter motivations and differences in attitudes towards hunting between social and ethnic groups can provide an understanding of why certain people undertake commercial hunting whereas others choose to kill leopards illegally. This information can be used to examine ways in which trophy hunting can be conducted in a more culturally relevant way, thus increasing its effectiveness as a potential tool for leopard conservation.

One way in which this may work is to explore reasons why trophy hunting takes place on so few communal black farms in South Africa. Community-Based Natural Resource Management (CBNRM) programmes have been set up in a number of southern African countries such as Namibia and Zimbabwe to encourage sustainable community development via trophy hunting (Lewis and Jackson 2005). Very few of these programmes exist in South Africa. The lack of trophy hunting of leopards on communal land means that community members have little incentive to stop illegal hunting of leopards as pests as they derive no income from them. Due to the government Land Claims process many properties belonging to private white landowners are now in the process of being taken over by local black communities. Providing incentives for

private landowners to conserve leopards via trophy hunting is no longer sufficient to ensure large enough populations of leopards are conserved in South Africa. Conservation and management solutions for leopards need to be culturally relevant to all landowners.

The political and regulatory structure in which trophy hunting functions can also affect its sustainable use as a conservation tool. Industries expand in response to economic factors and as they grow legislation and political structures develop in order to regulate and manage them. In a fast expanding sector such as trophy hunting the industry has grown more quickly than its regulatory structures, creating a situation where the government does not have the capacity to effectively monitor and regulate it (von Wielligh 2005). This momentum has created a situation in which unsustainable practices such as basing trophy hunting quotas of leopards on guesswork (instead of accurate field data) and widespread illegal hunting take place (Spong et al. 2000). An examination of the processes surrounding trophy hunting can identify problem areas caused by lack of effective regulation that need to be addressed to improve its sustainability.

6.1.1 The history of trophy hunting in South Africa

Trophy hunting can be defined as hunting of wild animals or game by a paying client and is also known as recreational, sport, safari or tourist hunting. This form of hunting is often motivated by the desire for prey with attributes such as large horns or body size for their worth as trophies and may also be conducted for pleasure derived from tracking and chasing quarry species (Leader-Williams 2009, Lindsey et al. 2007, Loveridge et al. 2007).

Hunting for recreation and sport has been conducted throughout much of human history. Monarchs and aristocrats from Europe, Asia and the Middle East created hunting grounds used exclusively for their own recreational purposes, excluding local communities from utilising the wildlife and conserving it for their own enjoyment (Loveridge et al. 2007). The roots of modern trophy hunting can be traced to colonial sport hunting in North America and Africa in the nineteenth century (Adams 2009). During the colonisation of Africa, European hunters killed wild animals in vast numbers

for sport, food and trade purposes leading to massive reductions in numbers of game species (Lewis and Jackson 2005). In the African Cape, for example, populations of plains antelope and elephants were greatly reduced due to hunting (Booth and Cumming 2009). By the late 19th century many wildlife populations collapsed from hunting pressure, leading hunters to push for the regulation of hunting in colonial Africa out of concern for dwindling amounts of prey (Adams 2009). Thus colonial hunters became preservationists, and as a result national parks and wildlife reserves began to be set up across the British colonies (Loveridge et al. 2007).

Trophy hunting in Africa remained the activity of the elite, but by the 20th century it changed from being an activity defined by class to one defined by money. Wealthy foreign hunters travelled to Africa to hunt and re-live the times of the romantic colonial safari. Prior to 1974, Kenya was the main destination for recreational hunting but due to concerns of the Kenyan Government for declining wildlife numbers, the hunting industry was closed down. Hunters looked to other countries in southern Africa to supply demand for overseas hunting opportunities and wildlife trophies and the popularity of South Africa as a trophy hunting destination grew (Booth and Cumming 2009). Legislative changes in South Africa in the early 1990's also stimulated the growth of the industry (Booth and Cumming 2009). Before 1991, all wildlife in South Africa belonged to the state but in 1991 the Game Theft Act was passed to regulate game ownership and deal with theft and illegal hunting on private land. This act devolved responsibility of wildlife management from national government to landowners, gave landowners rights of ownership and use of wildlife on their land and allowed them to benefit financially from it (Bothma et al. 2009). These rights are now given to properties that have the correct height of fencing (known as exemption) and private landowners are required to obtain an 'exemption permit' every three years to utilise the wildlife on their properties (A. McMurtie pers.comm).

South Africa is now home to approximately 10,000 game farms and 4000 mixed livestock and game ranches that contain a population of more than 1.7 million wild animals (Bond et al. 2004). Private land utilised for wildlife purposes is thought to cover 16.8% of South Africa (2007) and land continues to be converted from livestock farming to game ranches at a rate of approximately 5000km² per year (Bothma et al. 2009).

6.1.2 The socio-cultural context of hunting

People hunt animals for a wide variety of reasons including subsistence, recreation, as a culturally symbolic ritual or in retaliation for human-wildlife conflict. Hunters experience hunting as a highly cultural activity that occurs within specific social contexts (McCorquodale 1997). The reasons why certain people choose to engage in hunting are therefore heavily affected by their socio-cultural background. Moriarty and Woods (1997) in their analysis of the environmental ethics behind hunting of animals argued “hunting and meat eating by humans are “cultural” rather than “natural” activities.

The majority of trophy hunting clients that hunt in Africa are wealthy, middle aged, white adult males. An analysis of figures of the origin of clients that travel to South Africa to hunt shows that the greatest numbers come from the United States (56%) and Europe (40%) (von Wielligh 2005). von Wielligh (2005) provides an economic and demographic profile of these hunters. In 2004, 76.3% of trophy hunters surveyed by the Professional Hunters’ Association of South Africa (PHASA) belonged to above average income groups and 67% were aged 56 years and above. Trophy hunting is an expensive activity and hunting clients need large disposable incomes to afford hunting safaris. In 2004, the mean cost of a leopard hunt was approximately £5000 (von Wielligh 2005). This price includes species tariffs from hunting operators, government permit costs and taxidermy fees for mounting trophies. Additional costs include accommodation, travel and international shipping for trophies.

In the South African trophy hunting industry the majority of hunting operators and professional hunters are also white males, while black South Africans are often only found working in positions such as wildlife trackers and skinners. The dominance of white males is mirrored in almost all aspects of the industry from hunter demographics to trophy hunting journals. Kalof and Fitzgerald (2003) conducted an examination of photographs of trophy animals killed in the US and Africa in popular hunting magazines. Of the 792 images they examined, 95% of the hunters featured with their trophies were white adult males and only 2% of these were from racial minorities (Kalof and Fitzgerald 2003).

White males dominate the trophy hunting industry in South Africa for a number of reasons. Firstly the regime of Apartheid meant that only Afrikaners had the economic and political capacity to take part in the industry as hunting operators, landowners and hunters. The prevalence of white males in the hunting industry can also be explained by the cultural symbolism it holds for this societal group. As mentioned in Chapter 5, for many Afrikaners that live in rural areas nature is something that has to be fought against and overcome. This masculine desire to dominate nature reflects very closely the prevailing US and European cultural symbolism of hunting as a representation of maleness and power.

In the photographs that they analysed, Kalof and Fitzgerald (2003) found evidence that hunting remains very much a white male narrative that centres on dominance over nature and other social groups. In addition to almost all photographs representing hunts conducted by white males, hunters often had their hands symbolically placed on their trophies in ways that conveyed dominance and possession. The photographs also conveyed messages of gender and racial stereotypes. Women or black men were never depicted with guns when shown with white men thus emphasising their subservience and black men were almost always shown as assistants or helpers in the hunt.

The word trophy refers to a prize won after victory on the battlefield (Kalof and Fitzgerald 2003) and hunters preferentially hunt large male animals as trophies. Kalof and Fitzgerald (2003) discovered that over half of the images examined were of male deer with antlers. Males with 'weaponry' such as antlers provide a bigger challenge than female animals, as they can defend themselves. Dahles (1993) in her examination of the culture of recreational hunting in the Netherlands found that hunters preferred to hunt animals that showed 'fighting spirit' and wore 'weapons' such as tusked male wild boar and male deer as these were types of game that provide a bigger challenge. Characteristics that Dutch hunters found attractive in quarry species were aggression, courage and strength; qualities that are also associated with masculinity in Western society. In this narrative hunting symbolises a battle with nature and the identification between war and hunting is used to emphasise hunters' masculinity (Dahles 1993).

Changes in the cultural symbolism of hunting reflect social and economic developments in society (Dalhes 1993). Smalley (2005), in her assessment of gender and recreational

hunting, argues that the construction of hunting as a masculine practice began after World War II when hunting became centred on a post-war image of masculinity based on militarism and male bonding. Prior to this, recreational hunting was seen as the pastime of the elite and was defined less by gender and more by racial and class boundaries. The concern of the hunting elite was to differentiate their activities from other forms of hunting and to define their sport as legitimate and respectable (Smalley 2005). The post war change in the symbolism of hunting occurred as men's roles were changing in society and business and politics began to open to women. From this time on the dominant cultural view of hunting was as a solely male pursuit, a way of re-enacting war and a male rite of passage (Smalley 2005).

Similarities exist in the ways that hunting is viewed by different cultures. Hunting and obtaining trophies from wildlife hunts also denotes power, authority and dignity for a number of South African tribes. As described in Chapter 5, Venda chiefs wear leopard skins during their inauguration to symbolise their authority and power. These skins are either handed down within a family or the chief must go out and catch a leopard to obtain a new skin. Traditionally chiefs used spears to kill the leopard, and as leopards are very difficult and dangerous to catch, this ritual was seen as a test to legitimise the chief's right to rule. The practice of tribal chiefs wearing leopard skins is also common in other tribes, such as the Zulu tribe.

Hunting of dangerous animals as a male rite of passage is found in other black African cultures. The *morani* (youth) warriors of the Masaai in Tanzania conduct ritual lion killings known as *Ala-mayo* to express bravery and as a rite of passage into manhood (Ikanda and Packer 2008). *Ala-mayo* is now illegal in Tanzania but still continues as a cultural practice and has particular significance for lion conservation. Due to its illegality the Masaai are not able to easily organise unprovoked lion hunting parties for *Ala-mayo* but combine retaliatory lion hunts due to livestock attacks with *Ala-mayo* and reports of lion predation often trigger a swift response by the Maasai. Conservation of lions therefore has to incorporate factors such as *Ala-mayo* into any management plans in order to address the cultural context of lion killing (Kissui 2008).

Although there are similarities in the way that different racial and cultural groups view hunting as a test of masculinity and as a symbol of status or power these translate into

large differences in a material context. For Europeans and North Americans hunting is also an indicator of wealth and status. Only wealthy whites have enough disposable income to afford hunting safaris. Hunting as a sign of financial status is not the way in which black South African communities have encultured the leopard.

Macdonald (2005) in his analysis of the use of trophy hunting as a conservation tool for the ibex (*Capra ibex*) in northern Pakistan, provides an example of the different cultural meanings that a species possesses between social groups. Macdonald (2005) argues that for the foreign hunters ibex are an object of desire. These hunters are motivated by the desire to kill ibex and are defined by the willingness to pay to do so. Their desire to kill is not only driven by individual interests but is additionally stimulated by the culture of the wider trophy hunting community. This community gives rewards to hunters that shoot the biggest ibex thus conferring them with status. Wildlife is converted via trophy hunting into a commodity with exchange value (status) outside the local community in which it exists.

The trophy hunting programme has affected the relationship between local communities and the ibex. Ibex have a very different symbolism for the villagers than the foreign hunters and they use it as material and symbolic resource. For local people who can afford to hunt, the ibex provides meat but also represents a symbol of fertility and strength. Its organs are distributed to significant others across the hunter's social network to wish them good health and to denote the hunter's authority. Ibex meat is also distributed among family to express a commitment to their wellbeing and foster strategic community alliances. The institution of trophy hunting into the area has affected the symbolic meaning of hunting ibex for local people. Prior to the trophy hunting programme, symbolic value was attached to hunting prowess, but subsistence hunting is now seen by the wider community as a crime as it can reduce the economic and political benefits obtained from trophy hunting. Subsistence hunting is no longer seen as an act of material or symbolic value but as theft against the community (Macdonald 2005).

A parallel exists between the differences in cultural symbolism of the ibex for stakeholders in Pakistan, and the leopard in the Soutpansberg. For foreign hunting clients that come to shoot leopards, their symbolic value lies in the status they confer to

hunters that shoot large, powerful individuals. As with the ibex, the dead leopard is converted into status for the hunter within the wider hunting community. The symbolism that a leopard holds for local Venda communities is different. As discussed earlier in the chapter, Venda or Zulu chiefs wear leopard skins to symbolise their power and authority. The leopard skin confers status to the chief within his community, but the leopard is not converted into a commodity via money as it is with a foreign hunter who pays thousands of pounds to be able shoot a leopard.

6.1.3 Political ecology and trophy hunting

Political problems such as corruption, lack of effective regulatory framework and lack of capacity to develop good management can limit the conservation benefits of trophy hunting (Loveridge et al. 2007). For trophy hunting to work as a conservation tool, economic benefits from hunting need to accrue to those private landowners and local communities that bear the highest costs of living with carnivores. Without the direct accrual of revenues, landowners and farmers have little incentive to stop illegal hunting activities or conserve wildlife habitats as they only perceive leopards to be a drain on their resources (Leader-Williams and Hutton 2005).

The way in which revenues are shared within a community and how they are used are critical for its effectiveness as a conservation tool. If benefits are not shared locally and are retained by a centralised bureaucracy, revenues gained provide little opportunity to change attitudes or offsets costs for the people who are most affected by wildlife conflicts (Leader-Williams and Hutton 2005, Murphree 1993).

Corruption can have a negative impact on wildlife conservation by reducing the availability of funds, encouraging ineffective law enforcement and increasing the over-exploitation of resources (Leader-Williams et al. 2009). Many areas of conservation priority occur in developing countries with high levels of corruption (Leader-Williams et al. 2009). Smith et al. (2003) conducted a study on the impacts of corruption on conservation outcomes and found that poor governance scores which were inversely related to corruption levels were strongly correlated to the loss of black rhinos and elephants in Africa. Recreational hunting is often linked with corruption, particularly in poor counties where foreign hunters are prepared to spend large amounts of money to

obtain wildlife trophies (Leader-Williams et al. 2009). Corrupt activities in trophy hunting include accepting bribes for hunting permits, using political influence to allocate hunting rights and unethical hunting practices such as overshooting quotas, shooting females in male-only quotas or luring animals out of protected areas with baits (Lindsey et al. 2006). Corruption can have serious impacts on the sustainability of commercial hunting. Exceeding hunting quotas or shooting females can lead to population decline in the quarry species (Spong et al. 2000) as shown later in Chapter 7.

6.1.4 Trophy hunting as a conservation tool in local communities

Government wildlife authorities have made attempts to use commercial wildlife hunting as a means of promoting sustainable development for black communities in southern Africa via Community-Based Natural Resource Management (CBNRM) programmes. These include the CAMPFIRE project in Zimbabwe, ADMARE in Zambia and other similar programmes in Tanzania and Namibia (Lewis and Jackson 2005). Although these programmes were created to encourage sustainable development in local communities they have the added benefit of promoting wildlife conservation.

CAMPFIRE was set up in Zimbabwe to promote rural development by giving local communities rights of custodianship over wildlife on communal land (Bond 2001). Legislation passed in the 1980's gave rural district councils the right to receive economic benefits from wildlife uses such as trophy hunting and between 1989 and 1996 rural district councils in the CAMPFIRE programme earned \$8.5 million from fees and leases to hunting operators, accounting for 93% of their income (Bond 2001). As a result of CAMPFIRE the attitudes of members of local communities towards wildlife showed some improvement and poaching was reduced in certain communal areas (Bond 2001, Murphree 1993). Revenues generated by CAMPFIRE were used by district councils for community projects, such as clinics and schools with some money going to individual households (Murphree 1993). However, as more district councils joined CAMPFIRE and revenues from wildlife utilisation increased, money going directly to households fell from \$19.40 per household in 1989 to \$4.49 in 1996 reducing direct economic incentives to conserve wildlife and wildlife habitats (Leader-Williams and Hutton 2005). One of the main problems of the system was that the majority of funds did not go directly to the local communities or households most affected by

wildlife conflicts but remained with the rural district councils (Leader-Williams and Hutton 2005). The district councils were encouraged to devolve 50% of revenue from wildlife utilisation to their wards but were not obliged to do so. Another reason for the limited success of the programme was that significant benefits were only accrued to individual households in areas where there was low human population density and a high abundance of trophy species (Loveridge et al. 2007). Human wildlife conflicts are often distributed unevenly among communities therefore benefits from trophy hunting need to target those households most seriously affected by the costs of living with wildlife (Leader-Williams and Hutton 2005).

Benefits from community based trophy hunting have also been noted in Zambia. The employment of community members as village scouts helped to improve the capacity of wildlife authorities to enforce wildlife regulations. This led to an increase in numbers of illegal hunters arrested and weapons seized. There is also some evidence that community attitudes towards wildlife conservation improved because of ADMARE. For example several communities shifted family property to reduce village encroachment on wildlife habitat that was helping to earn ADMARE revenues (Lewis and Alpert 1997). There is however, a lack of data to prove that these projects have resulted in significant reduction in poaching or produced shifts in local land utilisation towards wildlife conservation friendly land use practices (Leader-Williams and Hutton 2005).

A few programmes have taken place in South Africa combining community development with trophy hunting. In 2003, the Department of Finance and Economic Development implemented a system in which a number of CITES permits for leopards were allocated to certain communities within Limpopo Province. This system allowed a percentage of money from leopard hunts to be used by identified communities for school repairs, purchasing of books and medical equipment (von Wielligh 2005). The system was extended by the government in 2004. However, no data exists on whether this programme reduced community poaching of leopards or improved attitudes towards wildlife therefore it is impossible to assess its conservation benefits.

6.2 Landowner attitudes towards trophy hunting

Qualitative data on local evaluations of the trophy hunting system were collected via semi-structured interviews and questionnaires as described in Chapter 1 and further information on the trophy hunting process was obtained via archival research. The full range of stakeholders associated with trophy hunting of leopards in the Soutpansberg was interviewed in this study. This included staff from the Limpopo Department of Environmental Affairs and Tourism (DEAT) from the following sub-departments:

1. Trade and Regulations
2. Biodiversity
3. Environmental Law Enforcement
4. Louis Trichardt Service Centre

Members of the hunting industry were also interviewed including:

1. Professional hunting bodies
2. Hunting operators
3. Professional hunters
4. Hunting clients
5. Taxidermists

Other stakeholders interviewed included private and community landowners and conservation NGO staff. Participants were asked to describe the trophy hunting process in Limpopo Province, identify problems within the system and suggest ways they would like to see it improved. Landowners that did not conduct trophy hunting were asked why they chose not to and under which conditions they would support the use of trophy hunting.

As shown in Chapter 5, landowners' associations with leopards vary according to their membership of different economic, socio-cultural and land use groups. This affects the way in which they view the leopard in terms of its value in economic and non-economic terms and determines whether they utilise leopards via trophy hunting and ecotourism or destroy them as pests.

Hunting Game Farmers

Of the respondents interviewed, game farmers with hunting farms were the only land use group to undertake legal trophy hunting of leopards in the Soutpansberg. None of the other land use groups chose to do so. There are a number of reasons why commercial hunting is limited to this type of property. Commercial hunting farms are established for wildlife hunting; hunting is an integral part of the culture and community in which game farm owners work and live. Game farmers are familiar with the trophy hunting process and are therefore adept in how the system works, know how to obtain a hunting permit and deal with the complex bureaucracy.

These landowners view wildlife in utilitarian terms as a central commodity within the trophy hunting industry. Leopards are not given a particular importance above other species. As a manager of a hunting game farm stated:

“I don't see leopard hunting as a problem. It's an animal like any other animal walking around here.”

Trophy hunting of leopards is also seen by hunting game farmers as a way to afford running a trophy hunting business. Fees obtained from hunting leopards are high and therefore can recoup a larger amount of expenditure on a hunting farm than most other species. This was emphasized by a hunting farm owner who said:

“If we were not hunting leopards there is no way you can financially manage to keep the farm. It would be nice if you didn't have to hunt but if it's a leopard or eland or whatever to me it's the same. Taking a male leopard every two or three years I don't think it's going to make a big difference, either financially to me or ecologically to the leopards, it's going to keep the client happy in the end.”

Ecotourism Operators

Landowners engaged in ecotourism have similar utilitarian views towards the leopard and value it for the money it brings into their property. But as the leopard's economic worth as a tourist attraction depends on tourists seeing live individuals, ecotourism

operators have little incentive to conduct trophy hunting. Leopard hunting has no economic advantage for this group of landowners, therefore they have no familiarity with the trophy hunting process and choose not to engage in it. Both ecotourism operators interviewed did specify however, that they would consider hunting leopards if their numbers “were too high” increasing their economic losses due to game predation. One ecotourism operator conducted game capturing in order to sell game at auction in addition to tourism. The manager of this property stated that as he only makes a small amount of money out of selling game, leopard predation was not high enough to warrant hunting but, ‘If I did more captures it would be a problem.’ Ecotourism operators therefore are currently willing to tolerate leopards without hunting them but if their presence conflicts with the land use on the property they would consider trophy hunting.

Cattle Farmers

As discussed in Chapter 5, cattle farmers hold the most negative attitudes towards leopards and are the social group most prone to killing them outside of the trophy hunting process. Their perceptions are coloured by the view of leopards as stock raiders that destroy their source of income. No cattle farmers interviewed engaged in trophy hunting. This group of landowners universally regarded the trophy hunting process as either suspicious or too much effort to get involved in. Cattle farmers tended to distrust the complex process of trophy hunting and the intent of hunting operators approaching them to hunt leopards on their land. There are a variety of reasons that cattle farmers do not engage in the process of trophy hunting. As previously stated, this group is often highly suspicious of government regulations and outsiders. White cattle farmers belong to the socio-cultural group of Afrikaners and tend to view their existence as a fight against nature and the government. This attitude is partially related to the difficulty of raising cattle in the unproductive habitat of the Soutpansberg where calves may be taken by predators and the government does not have the capacity to deal with damage causing carnivores.

One cattle farmer said:

“I don't like Nature Conservation (DEAT), I can't work with them for the last twenty years.....Nature Conservation should talk and listen to farmers, they don't do their work, I am trying to make a living and have to fight animals.”

This suspicion of people outside their socio-cultural group is shown by the following quote from a cattle farmer:

“I was approached by a safari company but that petered out and nothing came out of it, this happened a few years ago. People are reluctant to bring in people from the outside even though they might get some income.”

The process for obtaining a leopard hunting permit is also highly bureaucratic and few people outside the hunting industry are clear exactly how to apply for a permit. This aspect of trophy hunting dissuades most land use groups from conducting trophy hunts. One cattle farmer explained that this was why he chose not to hunt leopards on his farm:

“I am not heavily into foreign hunting as there are too many regulations.”

Another cattle farmer said:

“There was a man on the mountain, a professional hunter who shot lots of leopards with CITES permits so he knows how to get a permit. But he told me that I needed photographs for my application but I don't have a camera. I would have to go down the mountain first and then come back up. It's too expensive and too much trouble.”

Environmental legislation also affects whether cattle farmers choose to engage in legal trophy hunting. Cattle farmers are not allowed to hunt livestock damaging leopards therefore they cannot directly gain income from problem animals. As described in Chapter 5, if a livestock predation event occurs, it is legal to shoot the leopard if it is reported in 48 hours to a local police station. Alternatively the cattle farmer can wait for a local environmental inspection team to verify if there is a livestock killer on the property and then issue a Damage Causing Animal (DCA) permit to allow the farmer to

shoot it. This process can take many weeks as there is often only one environmental inspection team per district so many cattle farmers choose to deal with problem animals themselves.

If cattle farmers cannot obtain income from damage causing leopards to cover their stock losses, the trophy hunting process is confusing and full of bureaucracy and they are allowed to shoot leopards legally, there is no incentive to hunt leopards via a foreign trophy hunting client. This creates a situation where cattle farmers shoot leopards as pests because they perceive them to be a drain on their resources out of proportion to their actual impact, as shown in Chapter 6. In addition, wildlife authorities are unable to collect figures on levels of this unregulated harvest as many cattle farmers prefer to 'shoot, shovel and shut up' rather than report the incident or wait for the environmental inspection team.

Conservationist Landowners

Conservationist landowners have a much more protectionist stance towards leopards and do not allow hunting of wildlife on their properties. These landowners do not need to conduct trophy hunting because they depend on non-agricultural sources of income such as property evaluation businesses, low scale tourism or retirement funds. They are therefore able to value leopards for their non-economic attributes such as their ecological importance in controlling prey populations, aesthetic values such as beauty and power and their symbolic role as a manifestation of nature. When asked why he didn't hunt leopards the owner of one conservancy property said:

“You can't farm a leopard, it's not on your property, it doesn't belong to anybody, you can't buy it in, it's part of nature, like a snake, it's not yours. You can't buy one at an auction to put on your farm.”

Some conservationist landowners also saw themselves as stewards of nature. The founder of the local leopard conservancy stated:

“I get a lot of satisfaction from knowing there are leopards and that they are safe on my property. I think if there were no leopard at Lajuma I would have felt totally different about the place.”

Despite their support of wildlife conservation, none of the conservationist landowners interviewed viewed trophy hunting as an appropriate conservation tool for leopards. This was in part due to their highly protectionist views towards nature which prevented them from being able to consider such an option. As the landowner of one of the conservancy properties stated:

“It is emotionally hard to deal with this idea.”

A second reason why this landowning group does not support commercial leopard hunting is that they view it to be open to corruption and prone to unethical hunting practices and therefore do not see it as a suitable conservation tool. The owner landowner of a conservancy property explained this when he said:

“I am wary of the current hunting process; it is not infallible and is prone to abuse.”

Another conservancy landowner stated:

“I have been a hunter so I know what it’s all about; I got a hunting license many years ago. It’s not hunting, they put bait out, it’s like starving somebody and then putting out water and when it comes out to drink you kill it. It’s inhuman.”

Community Farmers

Leopards hold no financial value to black community farmers in the Soutpansberg and are universally viewed as problem animals that are often snared or poisoned as a result. One of the reasons that there is so little uptake of trophy hunting in local communities is the mistrust in the process. This distrust may have its roots in the old Apartheid system when government legislation and structures disenfranchised local communities and curtailed their rights. When one community leader was asked if there had been any trophy hunting of leopards on their land, he said they had been approached by a hunting outfitter but mistrusted his motives and did not take the process any further.

One way in which community attitudes towards leopards could be improved and illegal hunting on communal farms reduced, would be to allow trophy hunting of problem

animals. If local communities could obtain money from allowing hunters to shoot verified stock raiders, this could be used to offset their stock losses, encourage them to conserve the wider leopard population and improve attitudes towards carnivores. This important issue will be dealt with in more detail later on this chapter.

Landowners with alternative income sources

As with conservationist landowners, landowners with alternative sources of income to agriculture have a protectionist stance towards leopards as they do not experience economic losses from leopard predation. The manager of a salt mine stated:

“I wouldn't consider doing it - because they are not a problem. I suppose we could have had more bushbuck if it wasn't for the leopard but it's not that we're losing money. The owner and his wife know I don't want to hunt them. I am just not out to.”

6.2.2 The CITES leopard trophy hunting permit system in South Africa

It is necessary to explore the trophy hunting process and the relations between stakeholders involved in the system in order to assess the ability of trophy hunting to work as conservation tool for leopards.

International trade in leopard skins is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Each country that has signed up to the Convention is responsible for setting up a national Management and Scientific Authority that grants CITES permits and monitors trade in endangered species (von Wielligh 2005). Trade in these species is regulated by a quota system and each country that is a signatory to CITES has a quota for the number of leopard trophies is permitted for export.

Hunting permits are allocated annually to each province by the Department of Environmental Affairs and Tourism (DEAT). DEAT is the national government body responsible for environmental management in South Africa. It formulates and coordinates policy on the environment and has the mandate to manage and conserve wildlife (von Wielligh 2005). The numbers of permits given to each province are based

on levels of complaints from landowners about problem leopards, estimated provincial leopard numbers and distribution and levels of species utilisation. Each of the nine provinces in South Africa has a DEAT department responsible for the allocation of CITES permits to individuals. Systems for granting trophy hunting permits differ between the provinces.

6.2.3 CITES application system in Limpopo

The application system to obtain a trophy hunting permit is unclear, often confusing for the applicant and is open to corruption. The effect of this is that few landowners understand how the process of applying for a permit works and therefore choose not to do so. This affects the potential of trophy hunting to be used as a tool for leopard conservation as many landowners are discouraged from trophy hunting by the bureaucratic application process.

Applications for the right to hunt a leopard are made at the local DEAT Service Centre Office. Each district in Limpopo Province has several service centres. The Soutpansberg area belongs to the Makhado local municipality in Vhembe District and applications for hunting permits go through the Louis Trichardt DEAT Service Centre. There are two other service centres in the district – Messina and Toyonda. In 2008, the landowner of the property on which the leopard hunt was to take place had the duty to apply for the permit, but in 2009 this was transferred to the hunting outfitter in charge of organising the hunt. The effect of this change was to cause confusion in people applying for permits as it was not advertised. Landowners continued to make applications instead of hunting operators but these were sent back to them.

Trophy hunting permit applications carry a fee of R2000 (~£175), plus an extra payment of R5000 (~£435) which is paid into a fund for the training of previously disadvantaged individuals in the hunting industry. As discussed later, this fee of R5,000 is not popular amongst landowners and hunters as they feel the government are imposing politics on a purely commercial activity.

Once an application form is completed, it is given to a local DEAT officer who assesses the application and supports or rejects it. For an application to be eligible for a hunting

permit, the property the hunt will take place on must have fencing and be at least 5km-8km² in size. Applications are supported by the local DEAT officer if they are accompanied by a management plan for the property, have proof of leopard presence, a range of habitat types, a relatively high frequency of leopard and prey sightings and have not had a hunt on the property in the previous year. These requirements for obtaining a permit are not written down however, and often landowners do not know exactly what criterion they need to fulfil to be able to qualify for a hunting permit. This lack of information on the application process has a number of effects on the trophy hunting system. Some landowners are discouraged from applying for a permit as they do not understand what is required to make a successful application, there are no available criteria to assess whether DEAT Officers are basing their decisions on sound scientific reasons for supporting a hunting application and the system is open to corruption. As the DEAT Officer has the power to support or reject applications based on unwritten requirements this leaves their position open to bribery. As discussed later several landowners stated during interviews that the only way to obtain a trophy hunting permit was to bribe a government officer.

Once a permit is granted it is done so for a single leopard and can only be obtained for the same property every two years. However, due to lack of government capacity no monitoring of hunts takes place making it possible for hunters to shoot more than one leopard or hunt on properties other than the one stated on the permit. This illegal hunting activity affects the sustainability of trophy hunting as it increases the leopard harvest and makes it impossible to obtain accurate data on off take.

Applications supported by the local DEAT officer are forwarded to the Trade and Regulation Office in the provincial DEAT department in Polokwane for approval by the Senior General Manager of the department. Once approved, the application is put into a lottery system in early December each year. Fifty names (plus 10% extra) are drawn from the lottery and the first 50 are given permission to market the leopard hunt at overseas hunting conventions. The remaining 10% of names are placed on a shortlist of applicants to be given a licence if any of the 50 ongoing hunts are unsuccessful (von Wielligh 2005).

The hunt can be marketed by the hunting outfitter for a maximum of three months. Once a client is found their details are forwarded to the DEAT service centre along with

the proposed dates of the hunt. The leopard hunt can then take place, but can only be hunted by the named client on the specific property detailed in the application. The hunt must be completed within a two week period. Hunting operators must notify the local DEAT officer of the outcome of the hunt within 2 days of a kill so that the skin can be tagged with a green hunting tag and a CITES export permit is then granted (von Wielligh 2005). Once the trophy has been treated by a taxidermist it is exported to the international client with the legal certification. If the hunt is unsuccessful the hunting right is transferred to the next applicant on the shortlist.

Once hunts are completed, a hunting register should be filled in by the hunting operator, this register contains data on the hunt which is used by DEAT for compiling statistics on trophy hunting. Government officers often complain that these registers are left blank or only partially filled in. This leaves a serious gap in available data on details of individual leopards hunted.

6.2.4 Stakeholders in the leopard trophy hunting process

Fig. 7.1 shows the stakeholders in the trophy hunting system. As shown by the diagram there are a large numbers of stakeholders involved in the trophy hunting process, many with competing agendas. This adds to the lack of transparency in the system, increases the bureaucracy present and means decisions regarding trophy hunting of leopards are often based on commercial considerations rather than on sustainability.

Each province is divided into districts and within each district there is a Service Centre that employs a local DEAT officer. The officer approves trophy hunting permit applications, investigates illegal wildlife hunting and ensures provincial and national regulations are upheld in relation to environmental conservation and utilisation. Within the hunting industry, the main stakeholders in the trophy hunting process are foreign clients who pay to hunt leopards and the hunting operators who market the hunt abroad through hunting conventions, organise the hunt for the client, provide accommodation and employ staff to accompany the hunter on safari (professional hunters, trackers and skinners). Professional hunters are employed to ensure that a client has the greatest chance of getting a trophy and aid the hunt by setting baits and advising the client when to best shoot an animal. Both hunting operators and professional hunters must undertake courses at approved government hunting schools to qualify to operate. Hunting

operators need three years experience as professional hunters and must submit their hunting facilities to inspection by government officers to ensure that they conform to set governmental standards (PHASA website: www.phasa.co.za, retrieved 27/5/2010).

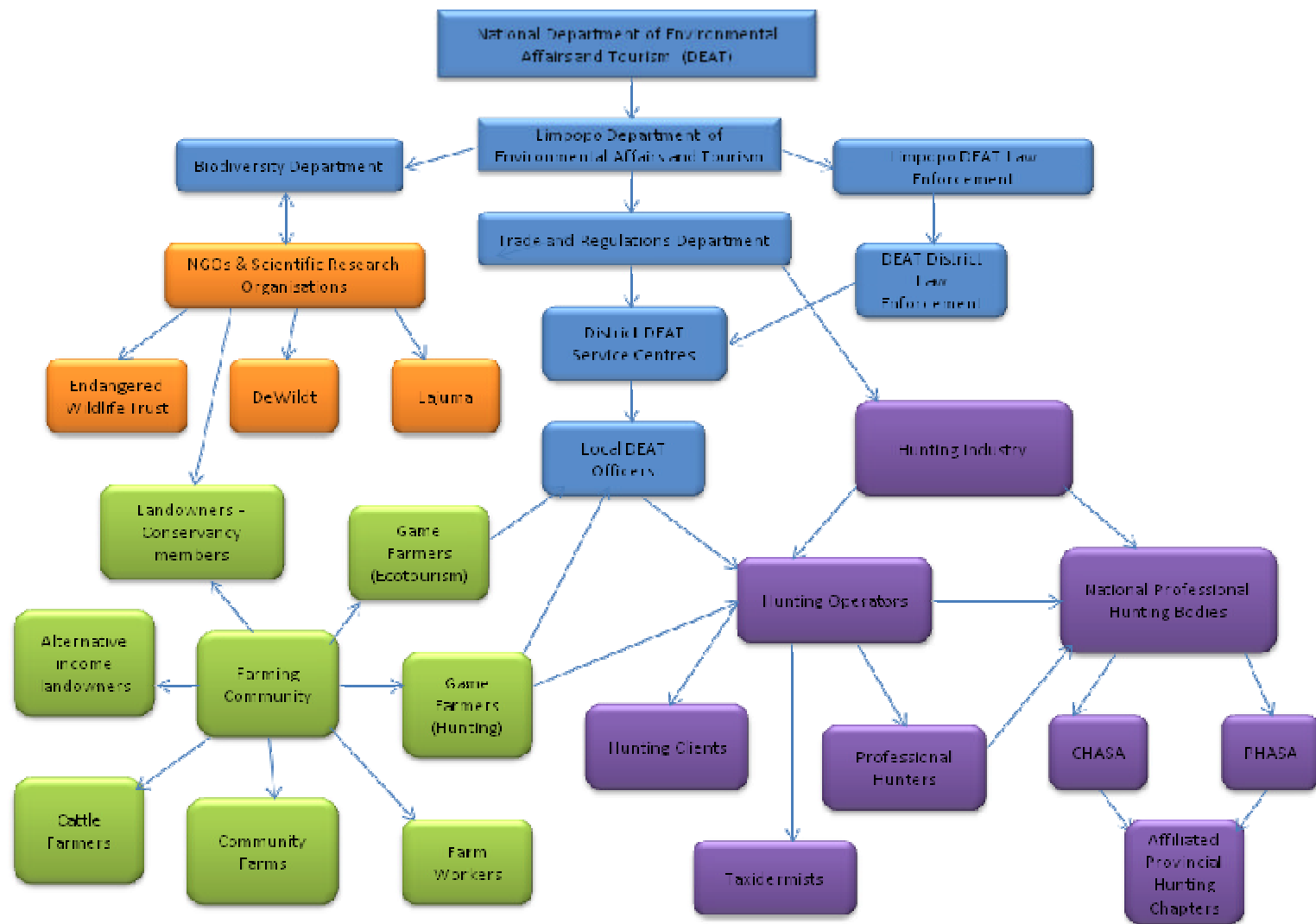


Figure 6.1 Diagram of stakeholder relations in the leopard trophy hunting industry

Taxidermists are another key industry stakeholder in the process. Once the hunting trophy has been obtained, it is taken to a taxidermist who prepares the skin or mount for export to the hunter's home country. Taxidermists are also responsible for checking that each trophy has the correct CITES documentation for export. The other main stakeholders are the landowners or community members on whose land the hunt takes place.

A number of additional stakeholders also have important roles within the trophy hunting process. Within DEAT there are three provincial government departments that are involved with leopard conservation and management - the Trade and Regulation Department, the Biodiversity Department and Environmental Law Enforcement. The Trade and Regulation Department are responsible for allocating and managing CITES quotas. The role of the Biodiversity Department is to keep records of wildlife projects in the province and give permission for them to be set up or decline where appropriate. This department also provides recommendations to the Department of Trade and Regulation on improving the CITES hunting process by making it more sustainable and accountable. It deals with reintroductions of animals, the keeping of captive leopards and scientific research. Currently the Biodiversity Department employs two staff to deal with mammal conservation issues in the whole of Limpopo Province. The Limpopo DEAT Law Enforcement department is responsible for enforcement and compliance of environmental legislation and focuses on issues such as illegal hunting. Environmental regulation and legislation is enforced at the provincial and district level by law enforcement officers who undertake inspections on private land and reserves and deal with cases of wildlife and environmental crime.

It is at the provincial level that leopard hunting quotas are set, decisions are made to lobby the international CITES body for quota increases and the administration of the trophy hunting system is planned and organised. As discussed, the department that sets and administers the leopard trophy hunting system is the Department of Trade and Regulation. One of the main aims of the department is to develop trade in the province, an aim at odds with biodiversity conservation. The responsibility for wildlife conservation lies with a different department – the Biodiversity Department. An officer from the Biodiversity Department stated that one of the biggest problems affecting wildlife management was the fact that the Biodiversity and Trade and Regulation

departments did not communicate effectively with one another and that the Biodiversity Department creates policy guidelines to improve the sustainability of commercial hunting but they are often not implemented. The officer went on to say that he had written recommendations on CITES quotas in 2005 and forwarded them to the Trade and Regulation Department but they were ignored. These recommendations advised that the province should have only 40 leopard permits per year out of concerns for sustainability but instead this was raised to 50 by the Trade and Regulation Department. The effect of this lack of departmental communication is that provincial hunting quotas continue to be based on commercial and political considerations rather than concerns for sustainability.

Other stakeholders in the trophy hunting process are non-governmental organisations (NGOs) such as professional hunting bodies and conservation organisations. The Professional Hunting Association of South Africa (PHASA) and the national Confederation of Hunters Associations of South Africa (CHASA) both promote the hunting industry in South Africa. These organisations lobby for the interests of the hunting industry, act as advocates of sustainable and ethical hunting practices and support the regulation of hunting activities and sustainable use of wildlife resources. Organisations like PHASA have a powerful lobbying voice within in the hunting industry and work closely with the Trade and Regulation Department to ensure that their interests are taken into account within the trophy hunting process.

Conservation organisations such as the Endangered Wildlife Trust and DeWildt Cheetah and Wildlife Trust are also stakeholders in both the leopard trophy hunting process and leopard conservation and management issues. The Endangered Wildlife Trust (EWT) is a South African conservation organisation that focuses on conserving species and ecosystems via applied fieldwork and research and direct engagement with stakeholders. EWT administer a national forum on leopard conservation, engage with the South African government on leopard management issues and are currently undertaking a review of the impact of increasing the CITES leopard quota in 2005. The DeWildt Cheetah and Wildlife Trust also filled a gap in provincial government that exists due to lack of money and capacity. Provincial DEAT used to employ an officer to investigate reports of damage causing leopards. This officer was responsible for investigating these reports, collecting data on problem leopards and organising

translocation of problem animals. This position was made vacant and the conservation DeWildt took over this role and staff from the organisation liaised with landowners over reports of problem leopards and translocated problem individuals to new areas. The fact that the government relies on an outside agency to deal with problem leopards shows the lack of capacity DEAT have to manage conflicts between humans and wildlife in the province.

6.3 Local evaluations of the current trophy hunting system

Through interviews landowners, local government officials, hunters and conservation NGOs provided assessments of the trophy hunting process and identified specific biological, political and social problem areas in the system.

6.3.1 Biological problems in the trophy hunting system

The main biological problems identified within the trophy hunting process are the inaccurate way in which quota levels are decided and the paucity of data collected after trophy hunts. Both hunters and government officers stated that trophy hunting quotas, on both national and provincial levels, are based on guesswork instead of accurate field data and that this has the potential to cause over-harvesting of leopards. An officer from the provincial Biodiversity Department emphasised this problem and suggested a way of improving the situation:

“There are currently no data on leopard numbers. Data could be obtained from camera trapping and to see if results of leopard hunts go up or down.”

The lack of accurate data on leopards in the province was also identified by landowners and professional hunters. The manager of a hunting game farm stated:

“As you may know there isn’t enough data on the leopard situation. I’d like to see a lot more data, I’d like to see decisions made on CITES quotas made on more sounder research than what we currently have.”

Hunters were also very aware that the government do not know the leopard population size in Limpopo Province. A local hunter said:

“Nature Conservation (DEAT) have no idea how many leopards are in Limpopo.”

The other main biological problem area identified was the lack of data available on the numbers of leopards killed through hunting. Hunting operators must complete a hunting register after a hunt in order to provide data on the individual hunted. Often the register is not filled in at all or done incorrectly. This means little data is available on the sex, age or size of individuals hunted and data from the register cannot be used to reliably assess the sustainability of trophy hunting quotas. Government officers were very aware of this situation and one of the main CITES permit officers in Limpopo stated:

“There is non-completion of hunting registers or it is poor. Some people submit their hunting registers up to 1 year after the hunts. It’s supposed to be 2 weeks. Some come through taxidermists, it’s supposed to come via the hunting operators. This creates a problem of missing data for National DEAT. No paper work is filled in by the hunter after the leopard is shot to provide statistics on the hunt.”

One way of improving the lack of data available on hunted leopards would be to ensure that hunting operators filled in a questionnaire after the hunt. These questionnaires exist but completing them has not been made a legal requirement of the hunting process. Data collection could also be improved by capturing hunting information that is provided in questionnaires onto a database to enable environmental authorities to examine and analyse data on the demographics of animals hunted. This would assist in ensuring the sustainability of trophy hunting as trends such as a decrease in trophy size can be used as an indicate of population decline (Loveridge et al. 2007).

6.3.2 Political and social problems

As discussed, some of main political problems within the trophy hunting process already described are that it is overly bureaucratic and is characterised by a lack of transparency. However, one of the most serious political problems affecting the use of trophy hunting as a conservation tool is the stipulation that it is illegal to hunt problem leopards on a trophy hunting licence in Limpopo Province.

Trophy hunting a verified problem leopard, thus allowing landowners or local communities that have suffered economic losses to obtain revenue would reduce illegal hunting of the wider population and give the species value on their land. Money

obtained from hunted leopards could be used to offset stock losses and be channelled back into properties. Giving the leopard an economic value could also change attitudes of leopards as pests to being a valuable asset.

As shown in Chapter 5, landowners that obtain money from trophy hunting leopards show an acceptance of economic losses they cause on their properties. Allowing community and cattle farmers to hunt problem leopards may have a similar effect and could reduce illegal leopard hunting. Despite the fact that the professional hunting association PHASA recommended in 2005 that a certain percentage of the trophy hunting quota should be made up of problem leopards, Limpopo provincial government does not allow trophy hunting of problem animals. A representative of the Trade and Regulation department stated that this policy is in force as it discourages people reporting damage causing leopards where they do not exist in order to make money from them.

Data from this study shows that there is a consensus among landowners supporting trophy hunting of problem animals. The manager of a salt mine stated:

“People would not care about the damage leopards caused if they could hunt them. If the system was so that if I report I lost cattle to a leopard they could be here within a day or two at least to see if it was a leopard and say ok on the grounds of what we've seen we can give you a permit and you can find a guy that wants to shoot a leopard, I'd say ok let's do this.”

Even landowners that do not support trophy hunting as a purely commercial enterprise said that they would be in favour if problem animals could be hunted on community land. The owner of a conservancy property stated:

“In South Africa it could generate income especially for communities. Livestock farmers lose livestock to leopards, if there was a quota, if they could give concessions to hunting in tribal areas with it staying in those local areas I could morally accept it. There are problem leopards, they are especially a problem in subsistence farming areas.”

The fact that commercial hunting of problem leopards is not legally allowed has a number of effects on leopard conservation and management. Firstly, it creates high levels of leopard poaching on cattle and community farms as neither of these land use groups obtain income from leopards. Secondly, it has created a system of illegal hunting in the province that the government is unaware of. Two interviewees admitted that they retain details of local hunters who want to shoot leopards and then match them with landowners that have problem leopards. The hunters are then able to shoot a leopard for a much lower price than they would pay on a hunting safari and the landowner uses the money from the hunting fee to pay for any stock losses. The high prices of trophy hunting fees have also contributed to this situation as they are too expensive for local hunters to afford. As a local DEAT officer said:

“Locally there is not much of a market for leopard parts and leopard hunting as it is not financially viable. You get a few South African hunters that hunt leopards but because this is expensive most are out priced completely. This is the only country with the Big Five but it is too expensive for local hunters to hunt leopard legally but they won’t pass up the chance to hunt a leopard if they hear about one illegally.”

The system of illegal local hunting is totally unregulated and no data exists on the numbers of leopards killed in this way. If wildlife authorities allowed trophy hunting of problem animals this could be regulated and information could be collected of the numbers of animals killed. A lack of data on levels of illegal hunting means that legal trophy hunting may be unsustainable as it takes leopards out of the population over and above the illegal harvest. As previously mentioned DEAT officials are not aware that this system of illegal hunting occurs. During an interview with an officer in the Environmental Law Enforcement Department, when asked about the level of illegal hunting in the province he said:

“Of illegal hunting there is only 20% that we don’t know about, in the past people didn’t report it but now they do. There are only about 5 cases of illegal hunting per year.”

A number of other political and social problems in the South African trophy hunting system were identified by stakeholders. These focus on either the difficulties involved in applying for a trophy hunting permit or the lack of government capacity to administer and monitor the process. The process of permit application was described by a number of individuals as being highly bureaucratic, with large amounts of paperwork to be filled in. Hunters and landowners who might otherwise have applied for a permit frequently said the high levels of bureaucracy discouraged them from doing so. A hunting game farm manager stated:

“The form used to be two pages but now it is 160 pages, so it is off-putting to fill in the official forms and hunters are not ones for paperwork.”

Provincial and district DEAT officers also identified the process as being highly bureaucratic. One officer stated:

“CITES permits should have shorter forms which would be more user friendly. It is not easy to get a permit due to the excess of red tape.”

Some stakeholders also described the trophy hunting permit system as lacking transparency and because of this it is very difficult to obtain a permit as it is not clear what is required to make a successful application. As a game farming manager said:

“They make it difficult for some people. People don't always know how the process works, it should be fairly simple to tell everyone how the process works. Permits are not easy to obtain, it's a stupid process, they make it difficult for everyone.”

Provincial and district DEAT officers also regarded the lack of information on the application process to be a serious problem in the system. The DEAT Officer for the local Service Centre stated:

“Those wishing to hunt don't actually know how this process works, they are not aware of the channel of command. Every single district should know how the CITES system works and if there are any changes, there should be a fair distribution of information, a few people know how the system works, it's all kept under wraps, the rest have no idea. You need a tax clearance form for the

permit but people were not sure if it was the hunting operators' or landowners' which was needed. Also the system has changed. Last year the landowner applied for the permit and this year it's the hunting operator that does it. A lot of people will not know that."

The fact that there are no official published regulations on how to qualify for a trophy hunting permit also adds to the non-transparency of the process. A staff member of a conservation NGO pointed out:

"There are no official regulations written down so we cannot take the government to task about the way they choose to grant permits for leopards. There should be a checklist of requirements and once these have been met, then the applicant should get a permit."

The lack of government capacity to administer the permit system effectively or to regulate and monitor trophy hunts was also identified as being a serious problem in the trophy hunting process. The Chairman of a professional hunting body stated:

"There is a problem with receiving permits. (DEAT) offices are understaffed, they don't return calls. Staff are not coming to meetings as they don't have the budget - these are the reasons people are not getting permits."

DEAT officers stated that the best way to ensure trophy hunting was monitored was to have staff out on all the hunts but this was not possible due to lack of capacity. One official from provincial DEAT said:

"CITES officers do not come out and ground truth the figures. Officials should be present at the hunt but are not."

The paucity of monitoring on trophy hunts facilitates illegal hunting activities such as shooting more than one leopard on a property or baiting for leopards outside the two week period stipulated in hunting regulations.

6.3.2.1 Social problems

For trophy hunting to work as a conservation tool structures must be in place for those that experience the greatest losses from living with carnivores to obtain benefits from trophy hunting in order to have incentives to conserve them. The majority of hunting permits in South Africa are taken up by private landowners and there is very little trophy hunting conducted on community land. Trophy hunting may encourage private landowners to see the leopard as a valuable species but it gives communities little incentive to stop illegal hunting of leopards as they receive no economic benefit from having leopards on their land. As mentioned previously in this chapter one reason there is little uptake of trophy hunting in local communities may be the mistrust in the process and lack of knowledge about how it works. This issue is particularly important because as previously mentioned, the Land Claims process is taking part in South Africa in which black communities are given back land they historically hold claim to. A large number of properties visited in this study had land claims on them meaning that they were soon to be returned to communities. Community ownership of land will grow in the Soutpansberg and unless appropriate management schemes are set in place rates of illegal leopard hunting may also increase.

Another factor identified by hunters and hunting operators as a barrier to applying for a trophy hunting permit was the Limpopo DEAT's decision to include a fee of R5000 (£435 approximately) with every permit application. The money is to be used to train previously disadvantaged people (PDIs) in the trophy hunting industry as professional hunters or trackers in order to build capacity in the community. The PDI training fund was set up in order to fulfil the trophy hunting industry's responsibility to the national government programme of Black Economic Empowerment (BEE). It was agreed at a Hunting Liaison Meeting between Limpopo DEAT in 2005 and the commercial hunting industry that voluntarily setting up such a scheme would be preferable to later being forced to comply with BEE for the industry. By 2008 R1 million was raised from trophy hunting fees. This money was used to set up a training course to train previously disadvantaged people as professional hunters. Many hunters, hunting operators and government officers complain about the fee and some landowners cite it as the main reason they do not apply for trophy hunting permits. One hunting farm manager stated:

“I don't feel positive about it, it's not included in the legislation, it's almost like blackmail and if you don't do it you're not eligible for the application draw, it's got nothing to do with the legislation.”

In response to being asked about his view of the R5000 fee, another game farmed owner declared:

“I am ethically against BEE, I am a racist, this is why I don't get a CITES permit, it is not policy, it is plain criminal.”

Many landowners were also not aware where the R5000 actually went. A buffalo breeding farm owner said:

“I do not know where this R5000 goes, I think it's for NGOs.”

6.3.3 Corruption

Stakeholders also identified a number of issues relating to corruption on the part of government officials in the trophy hunting process. Many said that they were unable to obtain a trophy hunting permit without bribing a government official. The potential for corruption in the process exists as there are no official regulations for obtaining permits therefore the local DEAT Service Centre Officer has the power to support or reject applications leaving the position open to bribery. Several landowners stated that the only way to obtain a trophy hunting permit was to bribe a government officer. A salt mine manager said:

“The problems with (DEAT) are corruption and just plain incompetence, the normal problems, don't know which ones the worst, corruption or incompetence. I have heard reports of corruption through the grapevine yes. The easiest way to get a permit is to bribe. I know one guy who gets three permits every year in return for giving (DEAT) wildebeest.”

A conservationist landowner also stated:

“According to some professional hunters there is bribery going on. At least one told me there is no way you can get a permit if you don't bribe someone. I don't know whether that's true but that's the perception that exists amongst hunters.”

The consequence of corruption in the trophy hunting process is that it reduces public confidence in the system and impacts upon its effectiveness as a conservation tool. Currently it is only legal to hunt one leopard every two years on a particular property in order to avoid overhunting. If landowners or hunting operators can bribe an official to obtain more than one permit for a property then this may cause over harvesting of leopards in that area.

6.3.4 Unethical hunting behaviour

Certain hunters identified unethical hunting behaviour by hunting operators or professional hunters as being a problem within the hunting industry. These practices included baiting for leopards full time on a property without having a hunting permit or using dogs for hunting leopards. One hunter stated:

“Some hunting operators are using full time baits all over farms for hunters to kill whatever is around without having the permit yet.”

Fulltime baiting is a serious problem as it continually attracts leopards to baits, drawing them out of their territories and as described in Chapter 4, when they are killed by hunters this creates a population sink. Under the conditions of a hunting licence it is only permissible to bait for the two week duration of the hunt to avoid killing too many leopards in the same area.

Unethical hunting behaviour also reduces public support for trophy hunting as a sustainable activity and provides the anti-hunting lobby with reasons to lobby against commercial hunting. A foreign hunter from the United States described the effect that unethical hunting activities have on the commercial hunting industry:

“People looking at hunting outfitters should ask themselves if they are honest, those who are not ruin it for everyone else just to make money.”

6.4 Discussion

The potential for trophy hunting to act as an effective conservation tool for leopards is affected by a number of political, social and procedural problems in the commercial hunting system. These problems centre on the trophy hunting process being highly bureaucratic, opaque and open to corruption. Quota setting is motivated by commercial interests with little input from government officers with concerns about wildlife conservation. These problems reduce the sustainability of trophy hunting by encouraging illegal hunting and discourage landowners that do not own hunting farms from applying for hunting permits as they do not understand how the process works so therefore choose not to engage with it.

As shown in this chapter there is no uptake of legal trophy hunting by cattle farmers or community landowners. This is due to a mistrust in the process itself, in the government and in others outside their socio-cultural groups. The result of this is that cattle and community farmers continue to kill an unknown number of leopards instead of using trophy hunting to offset their stock losses and channel the money back in their properties. This situation is compounded by the fact that landowners are unable to legally hunt problem leopards. If there were a clear connection between trophy hunting and the mitigation of human wildlife conflict, more landowners may undertake commercial hunting. This study has shown that a consensus exists amongst landowning groups supporting trophy hunting of problem animals.

Another problem with the trophy hunting system is that it is still very much dominated by white males. There are a lack of programmes in South Africa connecting black farming communities with trophy hunting. Only one example of a Community-Based Natural Resource Management (CBNRM) programme was found during this study. CBNRM is far more widespread in other countries in sub-Saharan Africa. The political situation in South Africa may be partly responsible for this. As the Apartheid regime ended recently in 1994 it is possible that CBNRM will develop later in South Africa

than it has in Zimbabwe, Namibia or Zambia. The government has taken steps to address the economic and political imbalance between racial groups by the process of Black Economic Empowerment. The R5,000 fee for previously disadvantaged individuals in the trophy hunting industry that is levied with each hunting application is one way in which the government is trying to improve the situation. However, the first training courses for PDIs only began in 2008 therefore the system still has far to go to address the racial imbalance in the hunting industry.

Recommendations for improving the potential of the trophy hunting process to act as an effective conservation tool for leopards are made in Chapter 8.

Chapter 7. The sustainability of trophy hunting in Limpopo Province, South Africa

7.1 Introduction

Unregulated hunting has led to the overharvesting, population collapse and extinction of a number of different species (Loveridge et al. 2007). Historical extinctions in South Africa due to hunting include the quagga (*Equus quagga*) and the blue buck (*Hippotragus leucophaeus*) which both became extinct in the wild in the nineteenth century due to hunting pressure from European colonists (Adams 2004). More recent declines, due in part to trophy hunting, include the African lion which has experienced a 30% population drop over the past two decades (Bauer et al. 2008).

Although unregulated hunting can lead to species extinctions, certain conservationists have argued that regulated trophy hunting has the potential to work as a conservation tool for wildlife by providing economic incentives for landowners and communities to reduce illegal hunting of commercially hunted species and conserve wildlife habitat (Leader-Williams et al. 2005, Lindsey et al. 2007). As a consequence, it is imperative that the biological effects of hunting on quarry species are fully assessed.

7.1.1 Trophy hunting as a successful conservation tool for wildlife

There is evidence that trophy hunting has helped to conserve some endangered species. Commercial hunting of cheetahs in Namibia for example has partly changed the attitudes of livestock and game farmers towards these predators. Between 1980 and 1991 landowners killed approximately 7000 cheetahs as pests (Marker et al. 2003b) but a combination of awareness building by the Cheetah Conservation Fund and the setting up of an annual Namibian CITES quota of 150 cheetahs helped reduce perceptions of cheetahs as pest species from 43% to 25% of farmers and created a decrease in numbers of cheetahs killed as problem animals (Marker-Kraus et al. 1996, Marker et al. 2003a). A further attempt to improve the conservation benefits of trophy hunting for cheetahs was made via an agreement between the Namibian Professional Hunters Association and a US NGO which linked trophy hunters with farmers that had problem cheetahs

(Leader-Williams and Hutton 2005). The scheme adds \$1000 for every animal killed which is then put into a fund for cheetah conservation. The cheetah population in Namibia has risen as a result. This scheme was not completely successful however, as CITES quotas of cheetahs are not fully utilised each year and 150-200 individuals are still shot annually. This suggests that the benefits from trophy hunting do not yet outweigh the costs of having cheetahs on private farmland (Leader-Williams and Hutton 2005).

As mentioned in Chapter 6, the community resource management programme CAMPFIRE in Zimbabwe that gives local communities the right to obtain money from selling trophy hunting leases, has also led to an improvement in local attitudes towards wildlife and a reduction in poaching levels (Bond 2001, Murphree 1993). However, despite the existence of these two examples, there is still a lack of enough convincing long term data showing reductions in illegal hunting as a result of economic benefits from trophy hunting (Leader-Williams and Hutton 2005).

7.1.2 The conservation benefits of trophy hunting in South Africa

Trophy hunting has brought certain conservation benefits to wildlife in South Africa. As mentioned in Chapter 7 there has been a rapid growth of the commercial wildlife sector in South Africa. Large areas of land have now been set aside for trophy hunting and this has greatly increased the area of land available for wildlife habitat (Loveridge et al. 2007). Due to the vast increase in land for wildlife utilisation activities, South Africa now has higher numbers of wildlife than it has had for the last 100 years and classifications of rare or threatened species are decreasing (Bothma 2004). The reintroduction of game for trophy hunting purposes has also led to the recovery of a number of previously endangered species such as blesbok (*Damaliscus pygargus phillipsi*), white rhino (*Ceratotherium simum*), black wildebeest (*Connochaetes gnou*) and the Cape mountain zebra (*Equus zebra zebra*) (Flack 2002).

7.1.3 Biological problems associated with trophy hunting

Although trophy hunting has the potential to provide conservation benefits for wildlife such as a reduction in illegal hunting and the expansion of wildlife habitats, it has been found to have a number of biological, behavioural and genetic effects on species population dynamics that can affect the sustainability of hunting off-take. These include overharvesting due to excessive quotas (Caro et al 2009, Spong et al. 2000), behavioural effects such as increased levels of infanticide (Loveridge et al. 2007, Packer et al. 2009, Whitman et al. 2004) and long term genetic change (Coltman et al. 2003, Jachmann et al. 1995).

For trophy hunting to work as a conservation tool, quotas must be sustainable and based on accurate field data on population numbers, species ecology and social systems (Spong et al. 2000). If quotas are not founded on scientific data there is a serious danger that over-harvesting may occur. Solitary carnivores such as the leopard are traditionally difficult to census as they have large home ranges and are rarely seen, so cannot be counted under normal field conditions (Balme et al. 2009, Henschel and Ray 2003). Due to the difficulty inherent in estimating numbers of large predators and the lack of capacity in many wildlife authorities to do so, trophy hunting quotas are often based on informed guesswork rather than population figures obtained from field data (Baldus and Cauldwell 2004). In Limpopo Province for example, leopard quotas are calculated from levels of complaints from landowners and estimates of provincial numbers based on habitat availability (von Wielligh 2005). The use of problem animal reports to set quotas suggests that trophy hunting quotas may reflect pressures to control carnivores rather than to conserve them (Packer et al. 2009).

Lack of monitoring of quota regulations may have a knock on effect over and above the off-take of a trophy hunting harvest. Wildlife management agencies often use male only harvests in order to protect the reproductive capability of adult females (Packer et al. 2009). A male-only trophy hunting quota for leopards exists in Tanzania but research has shown that females are being taken under this system due to lack of regulation (Spong et al. 2000). Spong et al. (2000) examined the sex ratio of leopard trophies shot by hunters in Tanzania using sex-specific molecular markers. Of the 77 samples taken from individuals shot between 1995 and 1998, 28.6% were found to be females

although all skins were tagged as male specimens. This shows that hunters were not making efforts to distinguish between males and females in the field.

The harvesting model used for quota setting in Tanzania assumes that only male leopards are taken and the effect of this violation of regulations is unknown. The regular removal of even small numbers of reproductive females has been shown to make populations more vulnerable to decline (Van Vuuren et al. 2005). Van Vuuren et al. (2005) undertook a modelling study of lion off-take in Botswana and sensitivity analyses indicated that adult female survival ability alone is the most important component of the model in terms of long-term population survival. In the short term, removing adult females has the effect of reducing overall population size which is compounded further as cubs of females shot also die. Over the long term, it creates a reduction in population breeding success as it removes breeding units (Loveridge et al. 2007). If quotas do not take into account female off-take, or the effect of this off-take is not investigated, quotas may be less sustainable than thought by wildlife authorities.

Research undertaken on trophy hunted populations has shown that hunting can also have behavioural, social, reproductive and genetic effects on quarry species. Ruth et al. (2003) examined the responses of large carnivores to recreational hunting of elk and other big game in the Greater Yellowstone Ecosystem and found that disturbance caused by hunting had an impact on movement behaviour. Using telemetry, the data showed that grizzly bears (*Ursus arctos*) moved towards hunting activity in order to utilise meat discarded from hunter kills and cougars shifted away from the increased human activity and followed elk out of hunting areas (Ruth et al. 2003). These findings have implications for human-carnivore conflicts as hunting seasons may cause higher rates of carnivore mortality when increased human presence raises the chance for human-wildlife encounters or when carnivores leave reserves to avoid hunting disturbance.

Another important behavioural effect of trophy hunting is the increase in levels of infanticide in certain carnivore species caused by the removal of adult males from a population (Caro et al. 2009, Loveridge et al. 2007, Packer et al. 2009, Whitman et al. 2004). Infanticide occurs when new males take over harems or territories and kill the existing cubs of females to bring them into oestrus (Loveridge et al. 2007). Adult male

leopards defend territories that overlap those of two or three females and incoming males commit infanticide if they take over territory of current male (Caro et al 2009). Excessive trophy hunting of males has the potential to cause male replacement and infanticidal behaviour to become frequent enough to prevent cubs reaching adulthood thus increasing the risk of population extinction (Whitman et al. 2004).

Loveridge et. al. (2007), in a study of the impact of trophy hunting on the population dynamics of lions in Hwange National Park in Zimbabwe, found that when adult males were removed near to the park border, gaps were produced within the territorial structure of the population which were filled by new males from the interior of the park. One of the consequences of the replacement of territorial males or coalitions was increased levels of infanticide by incoming males.

Solitary carnivore species that exhibit infanticide such as leopards may be even more vulnerable to population declines than social carnivores as they have none of the advantages of cooperative breeding (Packer et al. 2009). Packer et al. (2009) tested the sensitivity of infanticidal species to over hunting via simulation models of predator harvests and predicted population declines from even moderate off-takes. To test the results of male adult removal via hunting on solitary carnivores, they examined the effects of trophy hunting on a hypothetical population of solitary lions and concluded that leopards may be even more sensitive to off-take than solitary lions. They also argued that the recent 36.7% range decline of leopards in Africa may partially due to overhunting (Ray et al. 2005). The full-scale effect of unsustainable off-take on leopards in countries such as Tanzania may not be apparent for a number of years as leopard numbers may have been affected in many areas by the large scale decline in lion population numbers with whom they compete (Packer et al. 2009).

To reduce the effects of infanticide on trophy hunted populations of carnivores, regulated age-based harvests have been proposed (Whitman et al. 2004). Simulation work by Whitman et al. (2004), using 40 years of data on lions in Tanzania, suggests that regulated hunting of lions can be made sustainable by hunting males over a minimum age threshold (6-7 years old). This ensures that young males have enough time to remain resident in order to rear their young, thus avoiding the additive mortality effects of infanticide on trophy hunted populations.

Species behaviour and breeding systems also need to be taken into account when modelling sustainable off-take rates as they can affect the ability of a population to respond to hunting pressure (Caro et al. 2009). Caro et al. (2009) modelled harvest rates of species subject to trophy hunting regimes and incorporated breeding system parameters such as harem size, paternal care and infanticide to examine the effect of their inclusion on population sustainability. They found that harem size increased sustainable off-take and paternal care and infanticide lowered it. Where males were monogamous, populations showed vulnerability to off-take even without paternal care. Leopards do not show paternal care in breeding systems but do exhibit infanticide. These models were then applied to trophy hunting data from Selous Game Reserve in Tanzania and it was found that quotas for leopards exceeded calculated sustainable off-take rates (Caro et al. 2009). As a result the researchers recommended a reduction of leopard hunting quotas in Selous Game Reserve.

Trophy hunting also has the ability to cause long term genetic change in quarry species particularly in sexually selected phenotypic traits (Coltman et al. 2003, Harris et al. 2002, Jachmann et al. 1995, Loveridge et al. 2007). This can have important implications for sustainable wildlife management if heritable traits are targeted (Coltman et al. 2003). Coltman et al. (2003) found an evolutionary response to trophy hunting in bighorn trophy rams (*Ovis canadensis*). Using quantitative genetic analyses from a 30-year study of a wild population of rams in which trophy hunting targeted individuals with rapidly growing horns, researchers found that body weight and horn size declined significantly over time as rams of high breeding value were shot at an early age and were not able to reproduce. Unrestricted trophy hunting resulted in the production of lighter rams with smaller horns. Similar effects have been seen in heavily hunted populations of African elephants owing increases of tusklessness which has been attributed to selective illegal ivory hunting (Jachmann et al. 1995).

For trophy hunting to work as conservation tool, quotas must be based on accurate evaluations of population size to ensure overharvesting does not occur. Populations of hunted species also need to be monitored to avoid detrimental effects such as female off-take in male-only quotas, infanticide and long term genetic change. These factors can affect the sustainability of hunting and cause population decline.

7.2 Methodology

7.2.1 Population viability analysis

Population viability analysis (PVA) is modelling tool that is commonly used in conservation planning to assess the decline and extinction risk of wildlife populations and to compare management options for endangered species (Brook et al. 2000, Morris and Doak, 2002). A number of PVA programmes are currently in use, the most popular of these being VORTEX, GAPPS, INMAT, RAMAS Age, RAMAS Metapop and RAMAS Stage (Brook et al. 1999).

To evaluate the accuracy of five commonly used PVA programmes including VORTEX, Brook et al. (2000) conducted retrospective tests on 21 long-term ecological studies. The study found PVAs to be accurate in predicting of the risk of population declines with predictions closely matching observed outcomes. Population size projections generated via the PVAs also did not differ significantly from reality. Brook et al. (2000) concluded from this study that PVA was a valid and sufficiently accurate tool for categorizing and managing endangered species.

Despite these results, the accuracy of PVA has been debated and caution has been advocated in the use of PVA predictions (Brook et al. 2000, Coulson et al., 2001, Reed et al. 2002). Debate around the accuracy of PVA models has focussed on the reliability and comprehensiveness of data input into simulations, the effect of spatial and temporal variation on vital rates of a population and whether it is possible to accurately predict if these will remain stationary in the future (Coulson et al. 2001). One of the main problems with PVA is that accurate data are often unavailable on ecological and behavioural parameters for a given species so are omitted in analyses thus affecting the accuracy of predictions (Morris and Doak, 2002).

However, PVA can be used as an important tool for conservation by comparing the effects of different management regimes on a species in order to provide conservation management solutions (Reed et al. 2002). This role does not place as much emphasis on the quantitative estimation of extinction risk but focuses on the relative ability of

different management decisions to provide acceptable conservation strategies (Murayama 2008, Possingham et al., 2002).

The population viability simulation programme VORTEX Version 9.50 (Lacy et al. 2005) was used in this study to model the viability of the leopard population in the Soutpansberg. VORTEX is a Monte Carlo simulation of the effects of deterministic forces and demographic, environmental and genetic stochastic events on wild populations of animals (Miller and Lacy 2005). The programme simulates a population by stepping through a series of events that describe an annual cycle of a typical sexually reproducing, diploid organism: mate selection, reproduction, mortality, increment of age by one year, migration among populations, removals, supplementation, and then truncation (if necessary) to the carrying capacity (Miller and Lacy 2005). The simulation of the population is iterated many times to generate the distribution of fates that the population might experience. VORTEX requires specification of many biological parameters so is best applied to the analysis of a specific population in a specific environment (Lacy et al. 2005).

VORTEX was used in this study as it is one of the most commonly employed PVA packages in conservation planning and was utilised in the 2005 Leopard Population and Habitat Viability Assessment Workshop in order to assess the national status of the leopard in South Africa (Daly et al. 2005).

7.2.2 Baseline model input parameters

A baseline model was built to represent the Soutpansberg leopard population. Full input parameters for the VORTEX simulation are shown in Table 8.2. All scenarios were run 500 times and each projection lasted for 100 years in order for long-term population trends to be observed. Extinction was defined as when only one sex remained and the Soutpansberg population was modelled as one population (Daly et al. 2005).

Inbreeding depression was included in model as it may have major effects on reproduction and survival, particularly in small populations. The impact of inbreeding was modelled as 3.14 lethal equivalents. This represents the median value estimated from the analysis of studbook data for 40 captive mammal populations (Ralls et al.

1988). Environmental variation for survival and reproduction were linked in the model. Environmental variation (EV) is the annual variation in reproduction and survival due to random variation in environmental conditions. It can affect both leopards and prey populations, which in turn impact upon leopard survival and reproduction (Daly et al. 2005). No catastrophes were included in the simulation.

7.2.3 Reproductive system

The mating system was set as short-term polygyny as individuals breed with several mates. The age of first offspring was defined as 3 years (females) and 4 years (males); females reach sexual maturity between 2½ and 3 years (Bailey 1993, Nowell and Jackson 1996, Hunter and Balme 2004) and males later (Bothma and Walker 1999). The maximum age of reproduction was set at 12 years following Daly et al. (2005). VORTEX assumes animals can reproduce throughout their adult life and does not model reproductive senescence. Individuals are removed from the model after they pass the maximum age of reproduction.

The maximum number of progeny per brood was defined in the model as four cubs. Studies have shown that leopards give birth to one to four cubs per litter. Mean litter size was calculated as 1.92 (SD = 0.38), taken as an average across estimates by Hemmer (1976), Martin and de Meulenaer (1988), Le Roux and Skinner (1989) and Mills and Hes (1997). The percent of females breeding each year was modelled at 50% (approximate IBI = 2 years) (Daly et al. 2005). Inter-birth intervals (IBI) for leopards have been reported to be as short as 15 -17 months to over two years (Martin and de Meulenaer 1988, Bailey 1993, Bothma and Walker 1999) and in the absence of specific data for the Soutpansberg population an intermediate value is thus most appropriate.

7.2.4 Mortality rates

Mortality rates used in the model were taken from 2005 Leopard PHVA (Daly et al. 2005) and are shown in Table 8.1. These rates were estimated using mortality data from Bailey (1993), Bothma and Walker (1999) and Martin and de Meulenaer (1988).

Table 7.1 Mean annual mortality rates for male and female Leopards by age class (adapted from Daly et al. 2005).

Females			Males		
Age class	Mean annual mortality (%)	EV (%)	Age class	Mean annual mortality (%)	EV (%)
0-1	40	8	0-1	40	8
1-2	10	2	1-2	14	3
2-3	10	2	2-3	14	3
3 yrs +	5	1	3 yrs +	7	1.5

7.2.5 Population size

Three levels of population size were used. The baseline population level was derived using the population size provided by CAPTURE for camera trapping survey one – 16 (se 2.1511) as shown in Chapter 3. The Soutpansberg Mountains cover an area of 3300km² (Willems et al. 2009) and this figure was then extrapolated to cover the rest of the Soutpansberg. Lower and upper population sizes were obtained by estimating the 95% confidence intervals for 16 (se 2.1511) as per White et al. (1982). 16 (se 2.1511) was used instead of 19 leopards per 100km² because it comes with a standard error calculated by CAPTURE which could be used to derive the upper and lower population sizes.

7.2.6 Supplementation rates

As it is likely that the Soutpansberg acts as a source for sink populations beneath the mountains where human caused mortality is higher, it was assumed there was no supplementation of leopard in the Soutpansberg from other areas.

7.2.7 Dispersal

It was not possible to model for dispersal in VORTEX as only one population was used for the simulation.

Table 7.2. Input parameters for VORTEX Simulation, VORTEX Version 9.50

Parameter	Value	Justification
Number of iterations	500	500 independent iterations were run for each scenario.
Number of years	100	Simulation was set to run for 100 years (approximately 14 generations) in order for long-term population trends to be observed.
Duration of each year in days	365 days	
Extinction definition	Only one sex remains	Extinction is defined in the model as no animals remaining of one or both sexes.
Number of populations	1	The leopard population of the Soutpansberg was considered to be a single population.
Inbreeding depression	Yes	The value for inbreeding depression was set as shown below.
Lethal equivalents	3.14	100% of the effect of inbreeding due to recessive lethal alleles.
Concordance between environmental variation in reproduction and survival	Yes	EV for survival and reproduction were linked in the model.
Catastrophes	0	No catastrophes were included.

Parameter	Value	Justification
Reproductive system	Short-term polygyny	Leopards do not have a monogamous mating system.
Age of first offspring	3 years (females) and 4 years (males)	VORTEX defines reproduction onset as the time at which offspring are born.
Maximum age of reproduction	12 years	The maximum age of reproduction was set at 12 years for the baseline model following Daly et al. (2005).
Maximum number of progeny per brood	4 cubs	
Sex ratio at birth	50:50	Equal sex ratio at birth
Percent adult females breeding	50%	The percent of females breeding each year was modelled at 50% (approximate IBI = 2 years) (Daly et al. 2005).
Percentage of adult males in the breeding pool	100%	All adult males were considered to be potential breeders.
Mortality rates	See Table X	Values used were taken from 2005 Leopard PHVA (Daly et al. 2005)
Initial population size (N)	528	Obtained using the population density estimate from CAPTURE for camera trap survey one – 16 leopards per 100km ² (se 2.1511).

Parameter	Value	Justification
Lower population level	396	Derived using lower confidence interval for the population density estimate.
Upper population level	660	Derived using higher confidence interval for the population density estimate.
Carrying capacity (K)	100%	Carrying capacity was set at 100%. Population saturation was assumed because of the comparatively high population density estimate for leopards and the small home range (13.9 km ²) of one female measured during the study. No environmental variation was added to carrying capacity as it was included in reproduction and survival.
Supplementation rates	0	
Dispersal	0	
Baseline harvest	28 leopards per year	Harvest to take place each year from year 1 to year 100 with 40% females and 60% males harvested.

7.2.6 Harvest rates

As leopards experience high rates of legal and illegal off-take, harvest rates were also included in the model. Harvest rates were calculated from data on legal and illegal leopard mortalities which were gathered from landowner interviews and were estimated for a period of ten years. The total number of leopards killed came to 28 individuals over ten years as shown in Table 8.3 and the area of all the properties interviewed combined equals 327.99 km². A figure for harvest level over the entire Soutpansberg was then calculated by extrapolating this data to cover the rest of the mountain range (3300km²). The figure for overall harvest level over one year was calculated at 28 individuals.

It is very difficult to obtain accurate data on leopard mortality rates. Landowners may not be truthful about the number of leopards they kill due to legal implications. Cattle farmers did admit to illegal activities such as using poison to kill leopards, arranging illegal hunts and shipping skins over the border to Zimbabwe. As cattle farmers are legally permitted to shoot livestock killing leopards, it is likely that the information they provided on their legal activities was close to the truth as they were open about their illegal actions. Other land use categories such as game farmers however, may not have spoken about the illegal hunting they conducted themselves, but frequently reported the illegal activity of neighbours. In many cases multiple reports were available from different landowners regarding the same hunting event and this information was used to cross reference and verify leopard mortalities. One well known example of illegal hunting occurred on a game hunting farm. Three separate landowners, all neighbours of the game farmer, reported that he had illegally shot a leopard there. One of the landowners had heard gun shots on the game farm, another had been told about the death of the leopard by labourers from the game farm itself and the third landowner had been told of the kill by a neighbour.

These data provide as clear a picture as possible of leopard mortality rates but may represent an underestimate of illegal leopard harvests on community farms as no direct data were available from these properties. A more accurate method to obtain data on leopard mortality rates would be to use mortality data from collared leopards but this was not possible due to the small sample size of leopards collared in the study.

Table 7.3 Leopard Mortalities across properties over a ten year period

Property	Property size (km2)	Trophy hunting	Illegal
Property 1	13.65	0	0
Property 2	5.64	0	0
Property 3	10.95	0	0
Property 4	14.98	0	0
Property 5	70	2	4
Property 6	11.3	0	3
Property 7	1	0	1
Property 8	15.44	0	2
Property 9	4.36	0	1
Property 10	26	0	1
Property 11	5.14	0	0
Property 12	6.18	0	0
Property 13	30	0	0
Property 14	10.86	0	0
Property 15	9.09	0	0
Property 16	6.8	0	4
Property 17	34	0	6
Property 18	22.6	0	0
Property 19	5	1	2
Property 20	10	0	0
Property 21	5	0	0
Property 22	10	1	0
Total Area size	327.99		
Total Number killed		4	24

PVA simulations were run to examine the probability of population survival at baseline (528), low (396) and high population levels (660) using the input parameters in Table 8.2. The harvest was set at the baseline level of 28 leopards per year and at a sex ratio of 40% female and 60% male off-take as per the 2005 Leopard PHVA (Daly

et al.2005). Off-take was higher for males as they have higher mortality rates and are preferentially targeted as trophies due to their larger body size (Balme et al. 2010).

7.2.7 Illegal harvests on community land

As little data were available for leopard mortalities on community land, further modelling was undertaken in order to explore the impact of different levels of illegal community harvest on population viability.

Four levels of illegal harvest were used - low harvest (2 leopards out of 28 were killed on communal property per year – baseline model), medium harvest (5 leopards out of 31), high harvest (9 leopards out of 35) and very high harvest (12 out of 38). Table 8.4 shows the harvest levels.

Table 7.4 Four levels of illegal harvest

Harvest	Communal land	Other properties	Total
Baseline	2	26	28
Medium	5	26	31
High	9	26	35
Very high	12	26	38

7.2.8 The effect of differential sex ratio off-take on population survival

As the regular removal of even small numbers of reproductive females has been shown to make populations more vulnerable to decline (Van Vuuren et al. 2005), the effect of differential sex ratio off-take was examined on population survival for the baseline and lower population levels. The baseline harvest (n=28 leopards) was used for this simulation and off-take was initially modelled at 40% for females and 60% for males. The harvest ratio was then changed to 50% female and 50% male, and then 60% females and 40% male in order to discover whether increased female off-take would increase the probability of population decline as has been found in other studies (Balme et al. 2010, Van Vuuren et al. 2005).

7.3 Results

7.3.1 Results of the baseline PVA

Table 8.6 shows the results of the baseline PVA which includes probabilities of extinction (PE) and mean population sizes (N) for the three different population levels baseline (528), low (396) and high (660). A baseline harvest of 28 leopards and a ratio of 60% male and 40% female off-take was used in this simulation. As shown in Table 8.6 there is zero probability of extinction in the baseline and upper level populations (PE = 0). The lower population level shows a very small risk of extinction (P=0.02).

Table 7.5 VORTEX simulations on baseline, low and upper population levels

Population	PE (final probability of population extinction)	N-extant (mean population size for remaining extant populations)	SD (N-extant)	N- all (mean population size)	SD (N-all)
Baseline	0.000	514.21	25.84	514.21	25.84
Lower	0.022	374.80	32.96	366.56	63.94
Upper	0.000	646.66	28.98	646.66	28.98

Figure 8.1 shows the mean population sizes for baseline, lower and upper population levels under the baseline harvest regime over 100 years. As can be seen from the graph all three population levels remain stable over this period of time and shown no declines. Figure 8.2. shows the probability of extinction for the baseline, lower and upper population levels under the baseline harvest regime over 100 years. The lower population limit of 396 individuals is the only one that displays any risk of extinction although this is very low extinction (P=0.02).

After the initial simulation the higher population size (660) was discarded from further analyses as it represents an overestimate of leopard numbers in the Soutpansberg. The baseline population level (528) was obtained using camera

trapping data from the southern side of the mountain and then extrapolated to cover the whole Soutpansberg. The northern side of the mountain is more arid, with less vegetation and few prey species. It is likely therefore that it may also have a lower density of leopards as carnivores have been found to be positively correlated with prey species (Karanth et al. 2004b). The overall population number of leopards for the mountains would therefore not be greater than 528 as it would reflect the less favourable conditions on the north side.

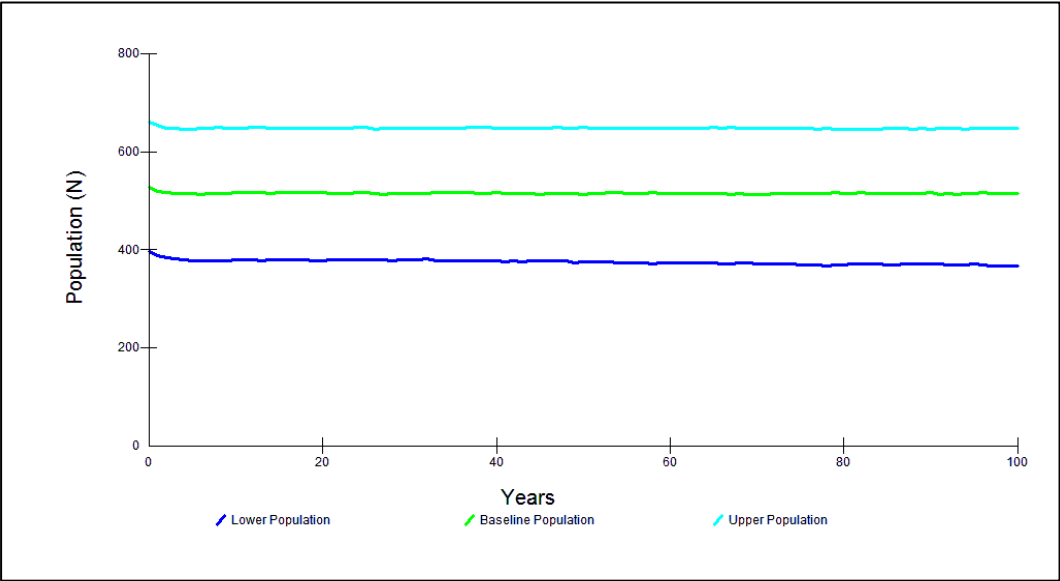


Figure 7.1. Graph showing mean population size for the baseline, lower and upper population limits under the baseline harvest regime over 100 years

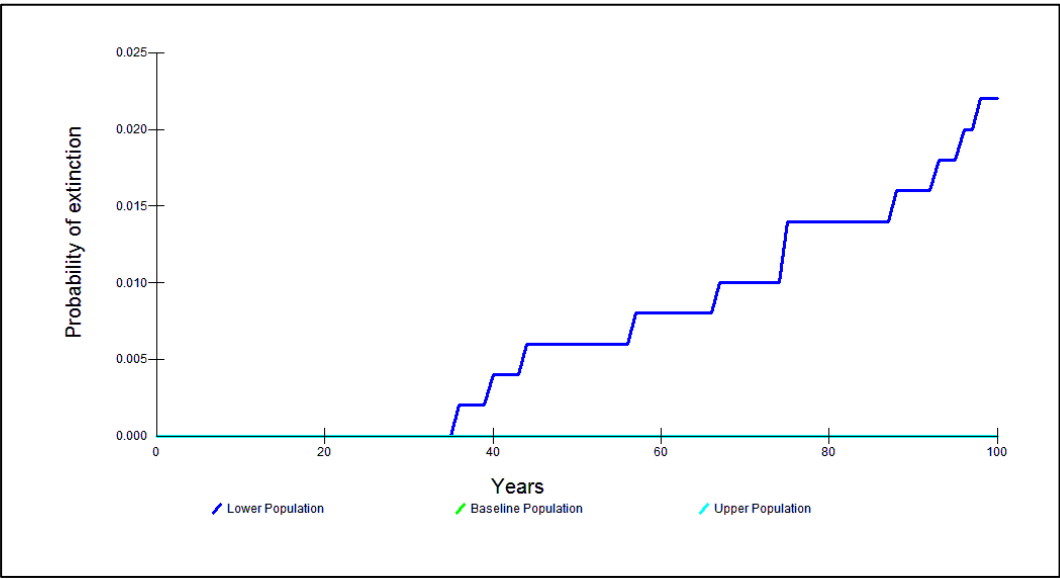


Figure 7.2 Graph showing the probability of extinction for the baseline, lower and upper population limits under the baseline harvest regime over 100 years

7.3.2 Illegal harvests on community land

Table 8.7. and Figures 8.3 and 8.4 show the probabilities of extinction (PE) and mean population sizes (N) for low, medium, high and very high harvests on the baseline and lower population levels. At the baseline population level there is almost no risk of extinction for all harvest regimes. The effect of different harvest levels greatly increases the risk of extinction at the low population level. At the baseline harvest (n=28) risk of extinction for the lower population level is 0.0022 but this increases to 50% with the very high harvest level (n=38).

Table 7.7 The results of PVA simulations for low, medium, high and very high harvests on the baseline and lower population levels.

Population	Harvest	PE (final probability of population extinction)	N-extant (mean population size for remaining extant populations)	SD (N-extant)	N- all (mean population size)	SD (N-all)
Lower	baseline	0.022	374.80	32.96	366.56	63.94
Lower	med	0.084	370.82	40.94	339.94	109.38
Lower	high	0.270	355.05	61.61	259.51	165.86
Lower	v high	0.508	341.01	74.93	168.40	178.03
Baseline	baseline	0.000	514.21	25.84	514.21	25.84
Baseline	med	0.000	510.46	28.30	510.46	28.30
Baseline	high	0.004	507.50	31.93	505.47	45.21
Baseline	v high	0.010	502.38	40.35	497.35	64.15

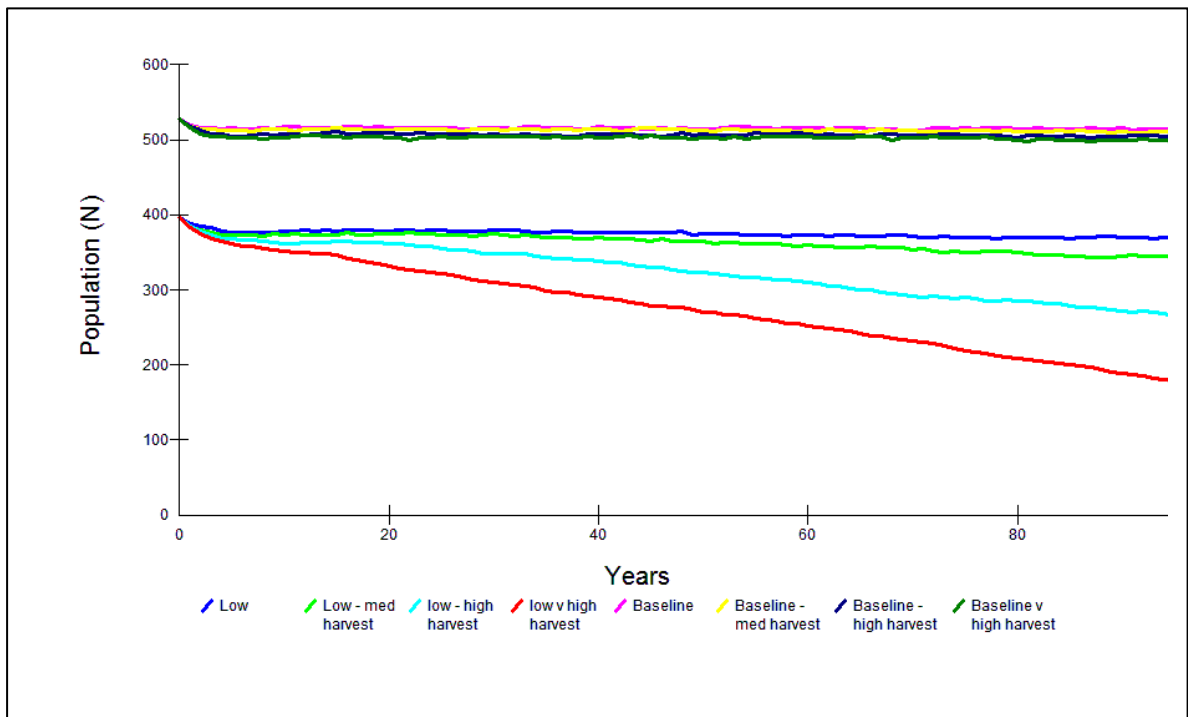


Figure 7.3 Graph showing mean population size for the baseline and lower population limits under different harvest regimes over 100 years

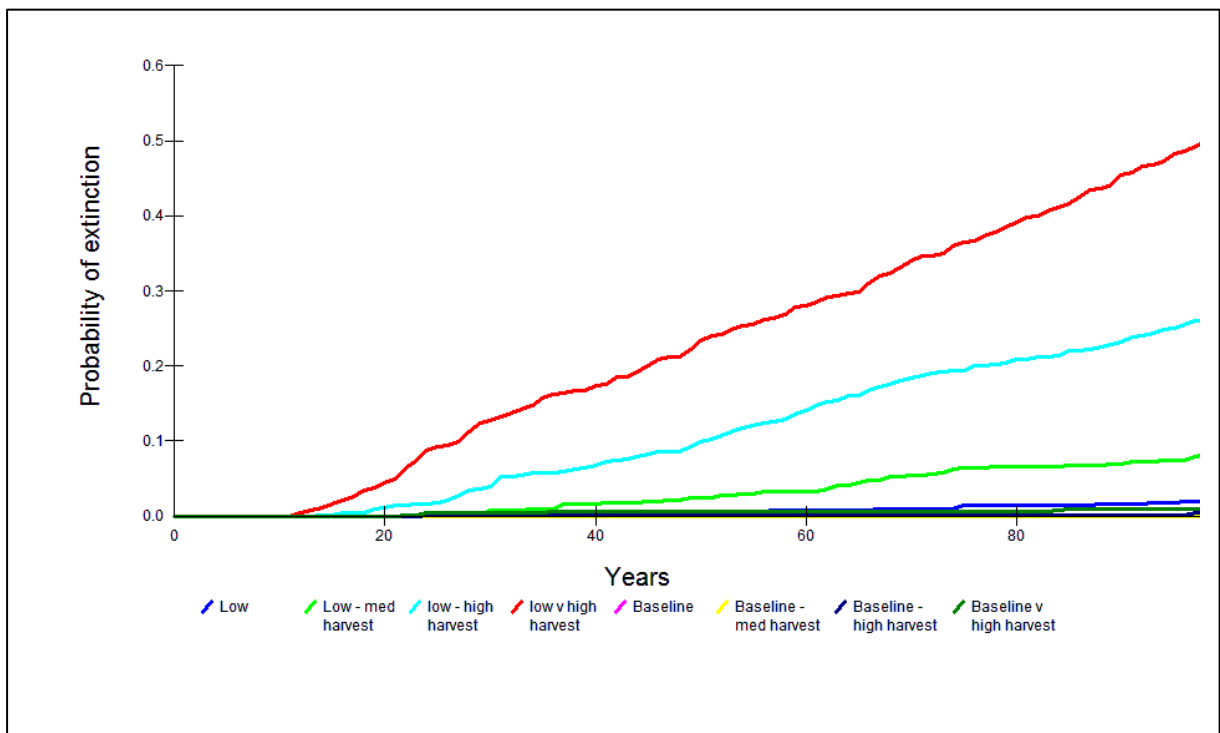


Figure 7.4 Graph showing the probability of extinction for the baseline and lower population limits different harvest regimes over 100 years

7.3.3 The effect of differential sex ratio off-take on population survival

Table 8.8 and figures 8.5 and 8.6 show the probabilities of extinction (PE) and mean population size (N) for the baseline and lower population levels with differing harvest sex ratios. Increasing female harvest causes a decline in the mean population sizes for both population levels and increases the risk of extinction. There is an almost 100% chance of extinction at the lower population level with a 60% female off-take under a harvest of 28 leopards.

Table 7.8 The results of PVA simulations with differing sex ratio off-takes

Population	PE (final probability of population extinction)	N-extant (mean population size for remaining extant populations)	SD (N-extant)	N- all (mean population size)	SD (N-all)
Baseline 40% female, 60% male	0.000	514.21	25.84	514.21	25.84
Baseline 50% female, 50% male	0.012	505.77	42.87	499.70	69.68
Baseline 60% female, 40% male	0.220	463.32	98.33	361.47	210.69
Low 40% female, 60% male	0.022	374.80	32.96	366.56	63.94
Low 50% female, 50% male	0.372	325.90	96.06	204.67	175.07
Low 60% female, 40% male	0.962	239.16	118.36	9.09	50.99

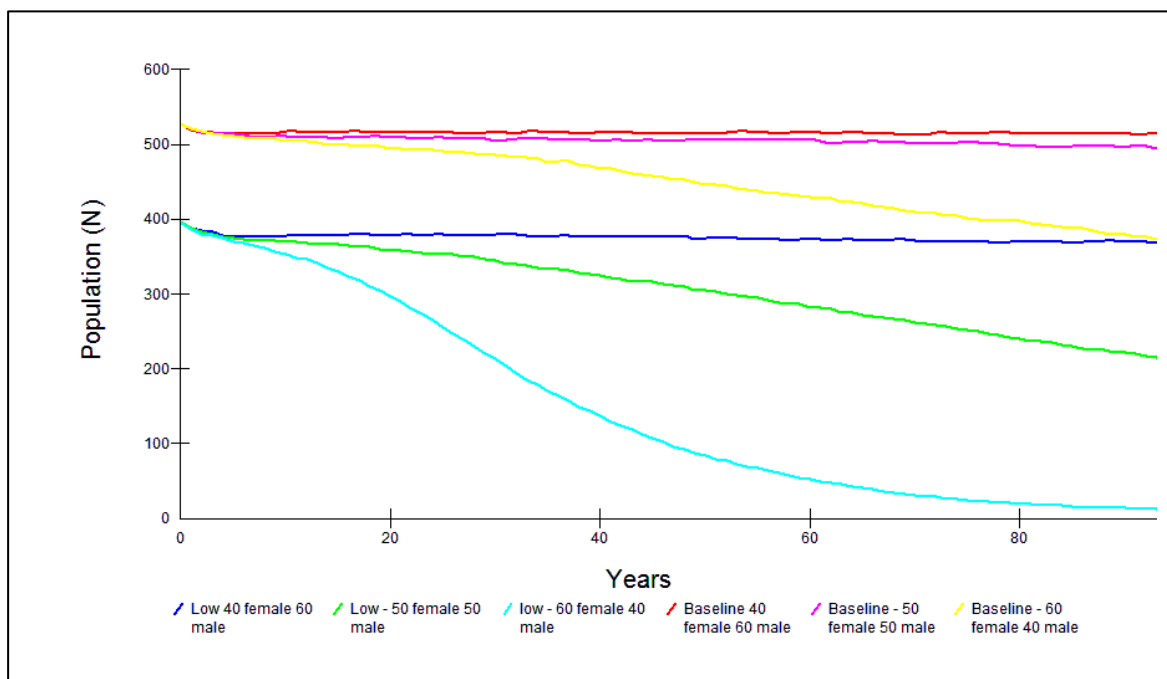


Figure 7.5 Graph showing mean population size for the baseline and lower population limit over 100 years with differing sex ratio off-takes

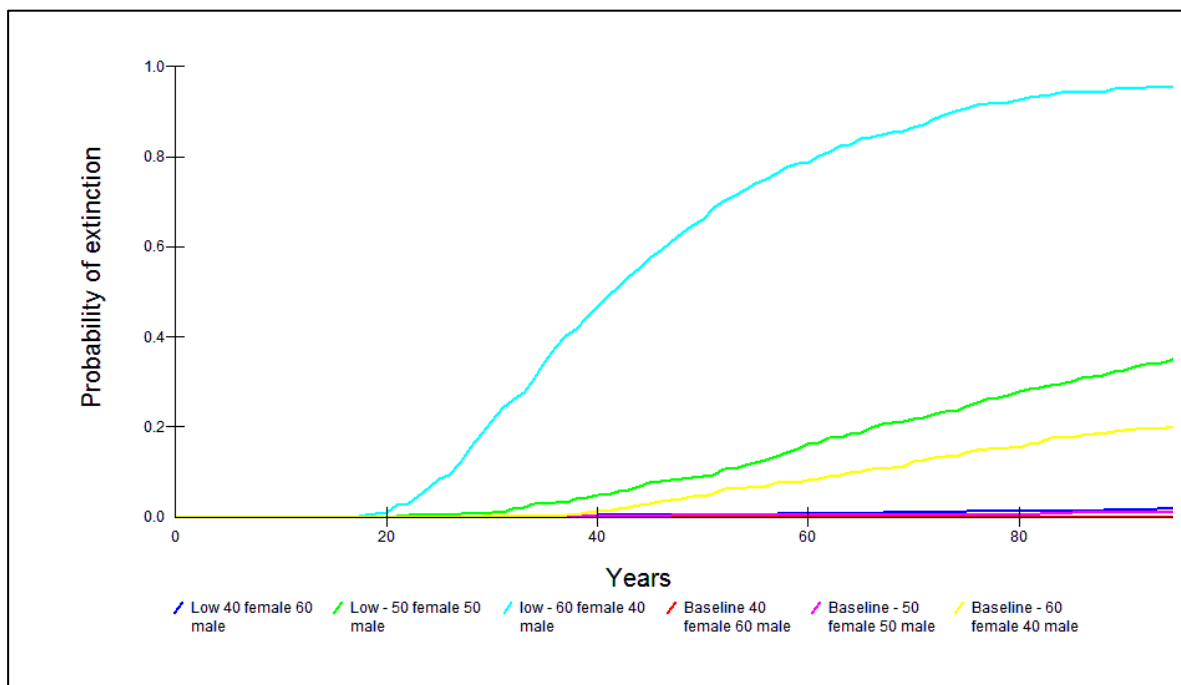


Figure 7.6 Graph showing the probability of extinction for the baseline and lower population over 100 years with differing sex ratio off-takes

The next section discusses the implications of the PVA results for commercial hunting of leopards in the Soutpansberg.

7.4 Discussion

If the leopard population estimate for leopards is accurate for the Soutpansberg (528 with a lower limit of 396 and a higher limit of 660), the leopard population is stable given the harvest rates calculated from landowner interview data (n=28). If the population is closer to its lower limit, and off-take is higher than the interview data suggest, then it is far less stable and in risk of decline.

It is very likely that the Soutpansberg leopard population is closer to the lower limit of 396 than the baseline number of 528 leopards. The figure used from CAPTURE represents an accurate estimate of leopard population density in the camera trapping survey area which was conducted on the southern side of the mountains, these data were extrapolated across the heterogeneous landscape of the Soutpansberg to obtain an overall population figure. As discussed in Chapter 1, the southern side of the Soutpansberg is less arid than the northern side and as a result has more productive vegetation and higher levels of prey availability. As carnivore populations are positively correlated in prey populations (Karanth et al. 2004b), it is very likely that leopard numbers are higher on the southern than the northern side. A more accurate overall leopard population figure would reflect the potential lower leopard densities on the north side of the mountain.

7.4.1 Leopard harvests

The results from these simulations suggest that the legal trophy hunting off-take of four leopards per year is sustainable assuming that these data are accurate. However, illegal harvests are much higher than legal off-take and may act as a source of additive mortality. Illegal harvest of leopards may also be higher than the results obtained by the landowner survey. No accurate data were available for leopard off-take on communal properties and it is possible that there may be higher numbers killed on communal land via poisoning and snaring than included in the baseline harvest (n = 2 out of 28 leopards). Testing of the PVA was conducted using four levels of community harvest –

baseline ($n = 2$), medium ($n = 5$), high ($n = 9$) and very high ($n=12$) in addition to the 26 estimated to be killed on other land use types. The probability of population decline and extinction was greatly increased under high and very high off take on the lower population level as shown in Table 8.7 with a 50% chance of extinction over 100 years with a high harvest. As the differences between harvest levels are relatively small, the population could soon be at tipping point in terms of its long term survival. This suggests that it could not sustain any further increases in legal off-take therefore wildlife authorities should not increase trophy hunting permit allocation any further in the Soutpansberg.

7.4.2 Female off-take

Analysis of the effect increased female harvest on the baseline and low population levels shows that intensifying female harvest causes a decline in the mean population sizes for both population levels and increases the risk of extinction. There is an almost 100% chance of extinction at the lower population level with a 60% female off-take under a harvest of 28 leopards. These results agree with the findings of previous studies that have found that female survival is the most important component of a PVA model in terms of long-term population survival (Balme et al. 2010, Van Vuuren et al. 2005). It is not possible to regulate the sex of animals killed illegally, but the risk of decline of the Soutpansberg leopard population could be reduced by enforcing a male-only trophy hunting quota therefore protecting females from the additive mortality of commercial hunting.

7.4.3 Data limitations

A number of limitations exist in using VORTEX to model carnivore population viability. Juvenile male leopards disperse from their natal home ranges to find vacant territories (Bailey 1993) but it was not possible to add in a parameter for dispersal in this PVA as VORTEX does not include dispersal if modelling only one population. Dispersal data from the home range analysis in Chapter 4 shows that young males in this study do disperse out from the mountain range to look for new territories. As the Soutpansberg may act as a source population for sinks beneath the mountain it is important to add in the demographic effects of dispersal which may act as a drain on

leopard numbers, thus causing the population level to be lower than the baseline figure suggests.

As stated earlier in this chapter, modelling studies have shown that the inclusion of information on breeding systems and reproductive behaviour in PVAs reduces population viability and causes additional decline in populations experiencing high male off-take (Caro et al. 2009, Packer et al. 2009). VORTEX does not currently include an option for modelling the effect of breeding systems and infanticide therefore it was not possible to include these parameters in the PVA. If it was possible to include these parameters, the Soutpansberg leopard population may show a greater risk of extinction and lower mean population numbers due to the added mortality caused by infanticide. The construction of a bespoke simulation PVA programme would allow for these parameters to be added into a model for the Soutpansberg leopard population to examine their effects.

7.4.4 Conclusion

These results represent the first modelling study on leopards in the area to include accurate demographic data from a field study and information on mortality rates. One of the main problems with PVA is that accurate data are often unavailable on ecological and behavioural parameters for a given species so are omitted in analyses thus affecting the accuracy of predictions. Previous attempts to model the viability of leopard populations in South Africa such as the 2005 Leopard PHVA (Daly et al. 2005) and the Status Survey of the Leopard (Martin and De Meulenaer 1988) were not able to include this level of data and had to rely on best guesses for important parameters such as population density or human off take.

This modelling study has highlighted information gaps still existing for the Soutpansberg leopard population which include accurate data on illegal hunting on community land and a population density estimate for leopards on the north side of the mountain. The inclusion of these data into future models could be used to calculate a more accurate population estimate and examine the effect of illegal harvests on population viability but the qualitative data used in this study are the most accurate to date.

The results of this simulation shows that commercial hunting quotas need to be based on accurate assessments of population numbers obtained from field data and must include information on mortality rates to ensure that commercial harvests are not having an effect of additive mortality on populations already endangered by illegal hunting. The research of Balme et al. (2010) and Van Vuuren et al. (2005) has shown that female survival is the most important component of a PVA model in terms of long-term population survival. Females therefore need extra protection to prevent the risk of decline of the Soutpansberg leopard population. This would be best achieved by enforcing a male-only trophy hunting quota.

Chapter 8: Trophy hunting as a conservation tool for leopards in the Soutpansberg Mountains, Limpopo Province, South Africa

8.1 Leopard population density and dynamics

The Soutpansberg Mountains are home to a high density of leopards (20 per 100km²). These data support the assertion of local landowners, hunters and the wildlife authorities that there is a large population of leopards in the mountain range. Extrapolation of the density estimate obtained from CAPTURE from the first camera trapping survey suggests that the population number of leopards in the mountain ranges lies between 396 and 528 leopards. As discussed in Chapter 7, due to the heterogeneous habitat and topography of the mountains, the real number of leopards in the Soutpansberg will be closer to the lower population limit of the PVA.

The results of the home range study Chapter 4 support the findings that a high density of leopards exists in the Soutpansberg. The small home range of the collared female leopard of 13.9 km² (95% MCP) suggests that the Soutpansberg is a prey rich area with prey densities high enough to allow leopards to live in large numbers and obtain enough prey to hold small home ranges. This figure is very small in comparison to home range estimates of female leopards in mountainous areas such as the home range of a female measured in the prey poor Stellenbosch Mountains (487 km², Norton and Lawson 1985). The home range of the female in this study is much closer to estimates from the wooded savannah areas of Kruger National Park and north-central farmland in Namibia (12.4 km², Bailey 1993 and 14.8 km² and Marker and Dickman 2005).

Data obtained from the movements of the sub-adult male shows similar patterns to dispersing leopards in Kruger National Park (Bailey 1993). The dispersal path of the male took him from his capture site on a leopard conservancy property, 52 km across the mountains to his last GPS signal 5 km from Louis Trichardt, the largest town in the area. These dispersal movements may provide preliminary evidence of sink-source dynamics acting upon the Soutpansberg leopard population in which leopards disperse from areas of high population density where they are relatively well protected, to vacant home ranges beneath the mountains where there is a higher risk of human-related

mortality. Source-sink dynamics are highly significant in areas where animals are legally harvested (Novaro et al. 2005). It is important to identify sources and sinks within a landscape in order to effectively manage species that exist within habitats with differing levels of anthropogenic pressure. Source populations may require increased protection from habitat loss and human persecution in order to protect metapopulations from decline (Balme et al. 2010). This could involve the prohibition of trophy hunting in the Soutpansberg.

8.2 Landowner attitudes towards leopards, human-wildlife conflict and leopard conservation

Chapter 5 showed that groups of landowners and farmers in the Soutpansberg hold differing attitudes towards leopards. The factors that most affect these attitudes are membership of a particular socio-economic group and whether the landowner derives economic benefits from leopards. These two factors determine whether leopards are viewed as financially valuable, a pest species that needs to be killed or a symbol of nature that requires conservation. Hunting game farm owners and ecotourism operators obtain money from leopards and therefore don't view them as problem animals even if they experience levels of game predation. Cattle and community farmers on the other hand see leopards as pests due to real or perceived livestock losses and because they derive no income from them. Human-wildlife conflict between livestock farmers and leopards is a serious issue as it has led to highly negative attitudes towards leopards and retaliatory killings. Lack of government capacity to deal with this conflict has exacerbated the problem.

8.3 Leopard diets and human wildlife conflict in the Soutpansberg

Interviews with hunters and landowners show that leopards experience high levels of human related mortality in the Soutpansberg. Leopards are shot and poisoned by livestock farmers for perceived predation events and an organised system of illegal hunting exists where a few landowners match up local hunters with farmers reporting problem leopards in order to hunt them. The money obtained from the illegal hunting fees is then used as compensation by the farmers. Local wildlife authorities are not

aware this system exists and it is completely unregulated. DEAT also have little staff capacity to investigate and deal with illegal hunting reports. Data gathered from landowners suggests approximately 28 leopards per year are killed illegally in the Soutpansberg. Actual levels of mortality due to anthropogenic sources may be higher.

Results from the dietary analysis show that leopards most frequently prey upon bushbuck (43.1%) and hyrax (22.9%). These results concur with those of previous diet studies conducted in Soutpansberg (Nemangaya 2002, Power 2002, Stuart and Stuart 1993, Schwarz and Fischer 2006). No trace of livestock or farmed game species were found in the leopard scats analysed. Evidence of kudu, warthog, common and red duiker and mountain reedbuck were found, but all these antelope species occur naturally in the area. These results show that leopards do not prey on livestock or expensive game species and most frequently take naturally occurring species that hold little economic value to livestock or game farmers. Despite this, as shown in Chapter 6, cattle farmers, ecotourism operators, hunting game farm owners and community farmers all complain of livestock and game losses to leopards. There are a number of possible reasons for the difference in real and perceived livestock and game predation. These include mistaken carnivore identity, misattribution of cause of death and socio-cultural prejudice. Another reason may also be that landowners and farmers only report predation of species that hold economic value for them, whereas leopards mainly feed on naturally occurring species that have low or no economic value.

8.4 Trophy hunting as a conservation tool for leopards in the Soutpansberg Mountains

Conservationists have argued that trophy hunting has the potential to be used as a conservation tool for commercially hunted carnivores such as leopards (Loveridge et al. 2007b, Lindsey et al. 2007, Balme et al. 2010). The way in which this could work is by using revenue obtained from legal hunting to offset the costs of conflict between humans and predators, thus improving tolerance towards carnivores and providing an incentive to conserve wildlife habitats (Leader-Williams and Hutton 2005). Money gained by landowners or local communities from selling hunting permits could be used to compensate stock losses, be channelled back into the community, encourage

toleration of wider populations of leopards on private and communal land and prevent illegal poaching (Balme et al. 2010).

As shown in Chapter 7, for trophy hunting to work as an effective conservation tool, economic benefits generated from it must be high enough to balance out the costs of living with large carnivores, must accrue to those that bear the largest losses and be distributed locally in order to positively affect attitudes towards predators and reduce illegal hunting (Leader-Williams and Hutton 2005). Hunting quotas also need to be biologically sustainable (Balme et al. 2010). To ensure sustainability they must be based on accurate population data and population trends must be monitored to prevent overharvesting.

If trophy hunting is not well regulated it has the potential to cause detrimental effects on the hunted population. These include increased infanticide, long term genetic changes and population decline. Even when quotas seem low, hunting may act as a source of additive mortality. This can occur as other sources of anthropogenic mortality such as illegal hunting are rarely included in the calculation of hunting quotas (Balme et al. 2010).

Figure 9.1 shows how trophy hunting can be used as a wildlife conservation tool. As described, quotas need to be based on sound population data obtained from accurate field studies and must also include other anthropogenic sources of mortality such as the legal destruction of problem animals and illegal harvests. Populations of hunted species need to be monitored to ensure that off take is sustainable and quotas must be adjusted if numbers begin to decline. Hunts should be monitored to ensure they adhere to existing regulations (i.e. only one animal shot of the right age or sex and on the correct property). Finally, political and economic structures should be in place for landowners or local communities on whose property the hunt has taken place to directly obtain revenue from the hunt. Unfortunately many of these requirements are not in place in the Soutpansberg.

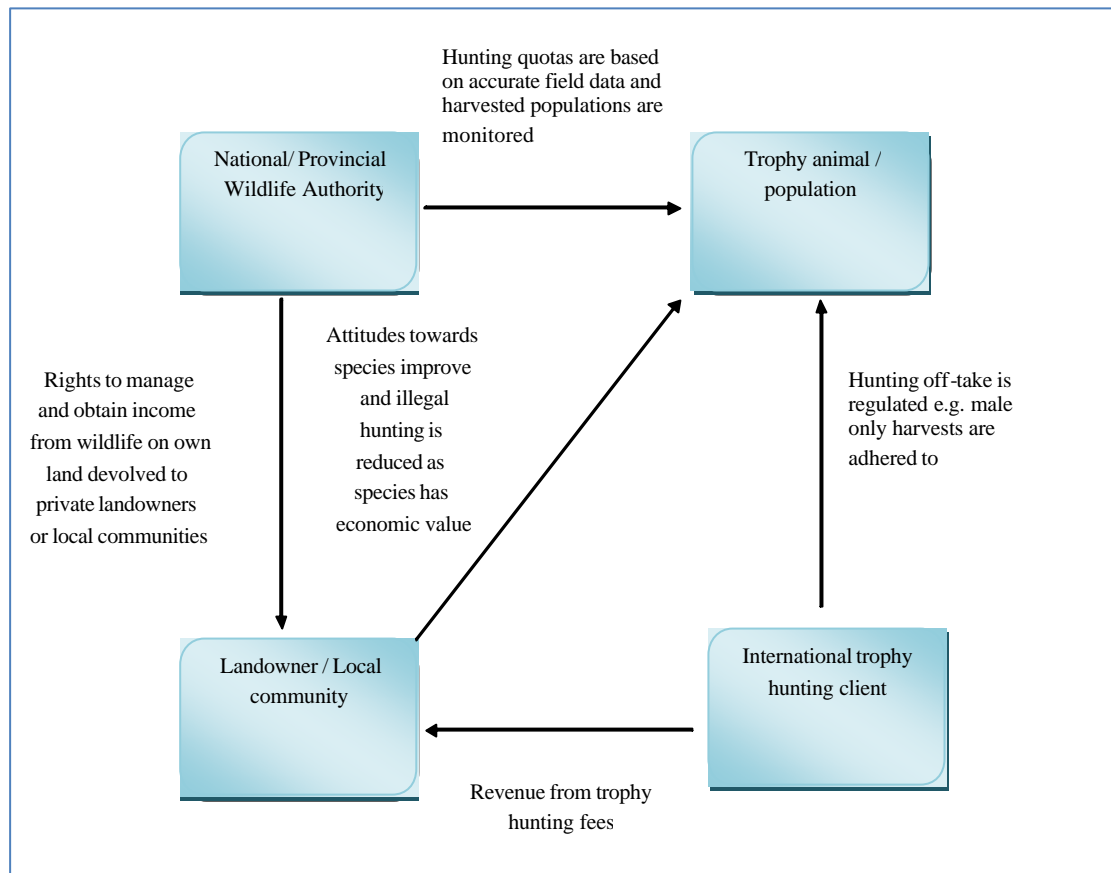


Figure 8.1 Trophy hunting as a successful tool for leopard conservation

8.5 Alternative methods of leopard conservation

As discussed in Chapter 1, alternative land management options to trophy hunting exist that can be utilised for leopard conservation. These include ecotourism on private or community land and the management of blocks of private farms as conservancies. This thesis has focused on the use of trophy hunting as a conservation tool for leopards, but as shown in Chapter 5 on landowner attitudes towards leopards, ecotourism operators and conservancy landowners show the highest tolerance towards leopards on their land and do not engage in retaliatory killings even if livestock and game are lost by leopard predation.

Further research needs to be undertaken into the effectiveness of ecotourism and conservancies as a conservation tool for leopards as these land use options provide a more sustainable alternative to trophy hunting leopards because they either do not

involve killing leopards in order to make a profit from them (ecotourism) or if trophy hunting does take place on conservancy land it would have a much lower impact on the population as conservancies could apply for a single hunting license for a leopard hunt over the whole area of the conservancy therefore hunting less individuals than they would be if each farm in the conservancy applied for a separate permit.

After examining the status of the leopard population in the Soutpansberg and discussing how commercial hunting can be used to conserve leopards, the next section investigates whether trophy hunting works as an effective conservation tool for leopards in the Soutpansberg.

8.5 Is trophy hunting sustainable in the Soutpansberg Mountains?

As shown in Chapter 7, if the leopard population figures are accurate, the current trophy hunting off-take is sustainable. Leopard harvests from legal trophy hunting are low (approximately 4 per year) and do not have a detrimental effect on the population. However, other sources of anthropogenic mortality such as illegal hunting are high and trophy hunting harvests may have an additive effect on mortality. If illegal mortality rates for leopards are higher than data suggest from landowner interviews they could lead to a serious population decline in the next 100 years. PVA modelling shows that at the lower population level, there is a 50% chance of extinction under a harvest regime of 38 individuals per year (this includes legal and illegal off take).

South Africa is one of the few countries that allows trophy hunting of female leopards. This factor affects the sustainability of trophy hunting off-take. Research has shown that the regular removal of even small numbers of reproductive females makes populations more vulnerable to decline (Van Vuuren et al. 2005). In the short term, removing adult females has the effect of reducing overall population size but over the long term it creates a reduction in the reproductive success of a population (Loveridge et al. 2007). An increase in the ratio of female to male off-take during PVA analysis caused a decline in the mean population sizes for both baseline ($n = 528$) and lower ($n = 396$) population levels and increased the risk of extinction as shown in Chapter 8.

The Soutpansberg population may act as a source for neighbouring subpopulations. This needs to be confirmed by further research. If this is the case, the population could be at a greater risk of decline as it provides a source for leopards dispersing into sink areas. If the population is not given protection from sources of anthropogenic mortality this source-sink dynamic can lead to further population decline.

8.5.1 Does trophy hunting work as a conservation tool by providing economic incentives to tolerate leopard populations on private and community land?

Trophy hunting does not currently act as an effective conservation tool for leopards in the Soutpansberg as it does not provide widespread economic incentives to tolerate leopard populations on private and community land as discussed in Chapter 6. The only landowners that engage in legal commercial hunting of leopards are owners of hunting game farms. This is because their properties are established for wildlife hunting, hunting is an integral part of their working culture and they are familiar with the bureaucracy of the trophy hunting process.

Landowners and farmers outside of this land use group do not conduct commercial hunting. Therefore they receive no economic benefit from leopards and have little incentive to tolerate them on their land. Leopards are therefore frequently killed illegally as real and perceived stock raiders by cattle and community farmers. There is low trophy hunting uptake in both of these groups due to their distrust of the complex and bureaucratic trophy hunting process. Where trophy hunting occurs on game farms, it does create positive attitudes towards leopards. Hunting game farm owners appear willing to accept losses of farmed game to leopards as they obtain money from hunting them. However, trophy hunting uptake is too low in the Soutpansberg to have a widespread positive effect on attitudes towards leopards and reduce illegal hunting.

The lack of broad landowner up-take of trophy hunting means that it does not currently work as a sustainable conservation tool for leopards in the Soutpansberg Mountains. The trophy hunting harvest may also be unsustainable due to the inclusion of female off-take and the additive effects of high illegal mortality. The next section provides management recommendations to improve the sustainability of trophy hunting and increase its economic and conservation benefits.

8.6 Management recommendations to improve the sustainability of trophy hunting

1. Use population data from camera trapping studies to inform management activities such as trophy hunting quota setting

It is essential that trophy hunting quotas are based on accurate population numbers of leopards to ensure that they are not being overharvested (Spong et al. 2000). The government may have little institutional or financial capacity to conduct and fund camera trapping studies but as concerns for the future of leopard populations in South Africa have increased, a number of leopard research projects have been set up across the country. Accurate population data from these studies must be used in establishing sustainable trophy hunting quotas.

2. Population monitoring

There are no rigorous data on the numbers or population trends of leopards anywhere they are hunted in South Africa and no regulatory framework exists for harvesting leopards established by assessment of the impact of hunting (Balme et al. 2010). Population trends of hunted species need to be monitored to ensure that off take is sustainable and quotas must be adjusted if numbers begin to decline.

3. Male only harvest

As the regular removal of even small numbers of reproductive females has been shown to make populations more vulnerable to decline, trophy hunting of leopards should be restricted to adult males only. This management recommendation was also proposed during the 2005 leopard PHVA (Daly et al. 2005) and has been instituted in KwaZulu-Natal as a result of research conducted on the sustainability of trophy hunting in this province (Balme et al. 2010). Due to high levels of legal and illegal mortality in a leopard population studied in KwaZulu-Natal Balme et al. (2010) proposed to the provincial wildlife authorities that only adult males over 3 years old should be legally hunted. At this age leopards are easily distinguishable from females by their size, more muscular body and wider neck and chest. Hunts should also be monitored to ensure that they adhere to age and sex regulations.

4. *Have lower harvests in source areas or total protection*

Management strategies must include awareness of source-sink dynamics. Wildlife authorities need to consider the management of leopards on a landscape scale and may need to adjust trophy hunting quotas or permit allocations to account for the need for lower harvests in source areas. This has been undertaken in the management of leopards in KwaZulu-Natal (Balme et al. 2010). Under advice from researchers, KwaZulu-Natal wildlife authorities have closed certain source areas to hunting to act as refuges from human harvest. Closed sources areas are used to ensure long term population persistence and provide dispersing animals for neighbouring sinks and other sources. Harvesting is permitted in sink areas as they are often less suitable for carnivore populations due to factors such as higher human density or activities, reduced prey availability and habitat quality.

Source populations need to be identified and must be large enough that adjacent sinks do not have detrimental effects on source populations. If other anthropogenic sources of mortality are stopped, populations in sink areas such as game ranching farms have potential for population growth as have lots prey and good habitat (Balme et al. 2010). This can only happen if leopard off-take from illegal shooting for real or perceived livestock losses is reduced.

5. *Reduction of illegal hunting*

Levels of illegal harvest are high in the Soutpansberg and are one of the biggest threats to leopards. If trophy hunting is to be sustainable, illegal hunting needs to be reduced.

8.7 Management recommendations to improve the economic and conservation benefits of trophy hunting

1. Trial hunting of problem animals

Hunting of problem animals should be conducted in Limpopo province. If landowners could hunt verified problem animals, money obtained from hunting fees could be used to offset stock losses, be channelled back into properties and reduce illegal hunting of the wider population. Daly et al. (2005) proposed trophy hunting of problem individuals in the 2005 PHVA as a management tool for leopards and Balme et al. (2010) also suggested that it might be possible to hunt verified problem leopards in Limpopo as the province has a large quota of hunting permits and high levels of human-wildlife conflict. A link could therefore be made between complaints of livestock raiding leopards and CITES hunts as there is the potential that a stock killing event may occur at the same time a leopard hunt is being planned. This would not be possible in provinces with much smaller numbers of CITES hunting permits. One problem with this system is that it might provide an incentive for false claims to increase chances of getting a CITES hunting permit, plus it also has the potential to reward landowners for poor livestock management. One way to deal with this would be to ensure that CITES permits are only awarded in response to verified livestock losses. This would require checks of properties reporting losses and an investigation of their livestock management systems to ensure poor livestock holding facilities are not contributing to losses. If government capacity is not available to do this, conservation NGOs exist that are able to take on this role.

2. Work with local communities to promote trophy hunting

Work needs to be undertaken to encourage the uptake of trophy hunting by cattle and community farmers in order to increase the economic and conservation potential of trophy hunting to all land use groups. This could involve liaison meetings with different land-use groups to explain the trophy hunting permit process and outline the economic benefits of commercial hunting. These meetings would have to be

conducted in a culturally relevant manner, using representatives from the same socio-cultural groups to frame and conduct them.

Having provided management recommendations to improve the sustainability of trophy hunting and increase its economic and conservation benefits the next section details additional research work that is required to improve data on leopard ecology and enable effective management of leopards in the Soutpansberg Mountains.

8.8 Future work

- A comparative camera trapping survey should be conducted on the north side of mountain to obtain a more representative population estimate for the whole Soutpansberg leopard population.
- Additional data are required to establish whether the Soutpansberg is a source for the wider Limpopo leopard population. This could be undertaken via additional GPS collaring of leopards and could provide further information on leopard mortalities in sink areas.
- An education programme for cattle and community farmers needs to be undertaken to reduce levels of human-wildlife conflict and illegal leopard hunting and encourage effective livestock management techniques.

The research in this thesis has utilised methodologies and styles of analysis from both the biological sciences and anthropology in order to allow an in-depth investigation of leopard conservation and management in the Soutpansberg Mountains. The final section reflects on the experience of undertaking interdisciplinary using a single researcher

8.9 Interdisciplinarity

Many projects set up to conserve wildlife focus solely on the ecological side of the issue with no input from the social sciences regarding analysis of the human aspect of wildlife conservation (Treves et al. 2006). As the attitudes and actions of humans that

live with carnivores determine the success of conservation interventions, it is crucial that the human dimension is recognised and incorporated into management plans (Sillero-Zubiri and Laurenson 2001).

In order to effectively address conservation issues between humans and wildlife an interdisciplinary approach is needed that involves an understanding of differing disciplinary perspectives and requires the integration of data and information from separate disciplines (Marzano et al. 2006). Interdisciplinary programmes often combine the work of natural and social scientists within one research programme and each brings different bodies of knowledge, methodologies, styles of learning and interpretation to that research. This study represents a novel attempt to use a single researcher to undertake interdisciplinary research that is beyond the scope of one discipline in order to obtain a more complete understanding of the conservation and management issues facing leopards in the Soutpansberg and the local communities that live with them.

8.9.1 Intersection and friction between biology and anthropology

The experience of undertaking interdisciplinary research had both positive and negative aspects. The positive side of undertaking interdisciplinary work was that there were often intersections between the two disciplines which provided opportunities to practice one method whilst engaging in the other. To facilitate integration between biological and anthropological methodologies in the project, the study design contained a number of these intersection points. For example whilst undertaking biological methodologies such as camera trapping, GPS collaring leopards and collecting leopard scats on different properties, regular opportunities arose for participant observation with local landowners. This enabled rapport building with informants and established levels of trust prior to engaging in more intensive anthropological methodologies such as face to face questionnaires. Engaging in social anthropological research such as semi-structured interviews also provided information on illegal hunting which was used later for the analysis of the sustainability of trophy hunting via PVA modelling.

There were however, some negative aspects to conducting anthropological and biological fieldwork together and at times the two methodologies caused friction with one another. For example in the course of conducting participant observation after

checking camera traps on a hunting game farm, the farm manager asked to see camera trap photographs that had been taken. This manager was a key informant on illegal hunting activities and it was important to ensure continued good relations, he was thus given access to the photographs. After viewing them he stated that he was using the photographs to discover if the property had any male leopards that could be hunted. This situation presented an ethical dilemma as illegal hunting had been reported on this property and it was possible that allowing access to the camera trap photographs may encourage further illegal leopard hunting.

8.9.2 Personal experience of undertaking interdisciplinary work

As I have training in both biological and anthropological sciences I did not have to face some of the main challenges experienced by interdisciplinary researchers from single science backgrounds. Prior training in both disciplines had provided an understanding of the theoretical background and methodologies in both biology and anthropology. I also had experience of undertaking interdisciplinary research in northern Cambodia on a project that combined camera trapping with participant observation and semi-structured interviews to investigate the presence of leopards in Mondulkiri Protected Forest and investigate human-wildlife conflict between local communities and leopards. This project gave me grounding in conducting interdisciplinary research.

Despite prior interdisciplinary training and experience, one of the main negatives of conducting research using both biological and anthropological methods was the large time investment that had to be made for both disciplines. Biological fieldwork such as camera trapping can be very time intensive and this often affected my ability to record anthropological data after a long day in field. The large time input required for each discipline was even more marked when it came to analysing and writing up both sets of data as each required different types of analysis, had to be written in different styles and the reading load of background literature was doubled.

Conducting an interdisciplinary study with just one researcher rather than separate biologists and social scientists prevents problems of miscommunication and misunderstanding between different disciplinary groups. It also enables one person to obtain a much wider picture of a conservation problem than would be possible using

only one discipline. However, the extra time requirement of performing an interdisciplinary role must be taken into consideration when planning similar research. In order to effectively conduct interdisciplinary work using one researcher, the individual has to be open to new ways of analyzing problems and be able to use methodologies that are very unfamiliar to someone who is used to conducting only biological or social science work.

As a researcher trained in the biological sciences, conducting an interdisciplinary thesis using anthropological methodologies has made it possible to gather information on trophy hunting that would not have been available to me solely as a biologist. Undertaking interdisciplinary work has provided data on the socio-cultural factors driving landowner and farmer perceptions and actions towards leopards and has also enabled me to gather detailed information on leopard mortalities. These data can be used to improve the sustainability of trophy hunting in the Soutpansberg and ensure that trophy hunting is promoted as a conservation tool in a more socio-culturally relevant way to the people that live in close proximity to leopards and ultimately determine their fate.

Appendix 1: Leopard Project Questionnaire

Occupation:

Date and time:

Name and Location of Property (GPS)

What is the main use of your property (Game farm, cattle farm, tourism, conservation, fallow land etc)?
.....

If cattle and / or game farm:

What are the other uses of your property (percentages for income generation)?

What species do you have on your farm?

Livestock
species.....

Game
species.....

Value of livestock and/or game (in
Rand).....

How many of these species non-native to the
area.....

Leopard populations

Do you have leopards on your property?
.....

If yes, how do you know this? (Tracks, scat, sightings,
photographs).....

Do you think the number of leopards in this area is low / moderate / high / don't
know?.

In the past 10 years do you think leopard numbers are falling / increasing /
remaining the same / don't know?

What are your reasons for this
answer?.....

Human-wildlife conflict

Have leopards caused any livestock/game losses on your property?

Yes/No

If so please describe each loss (time of day/night, type of animal, its age, cost and date).....
.....

Total cost of losses.....

If you have livestock and / or game do you use methods to protect them from leopards? (e.g leopard proof fencing, corralling of calves in the night, livestock guarding dogs etc?)

Yes/No

If yes please describe these methods.....

Trophy hunting

Do you agree with hunting of leopards?

Yes/No

Please give your reasons for this answer.....

Is trophy hunting conducted on your property? Yes/No

Please give your reasons for this answer.....

If yes - how often do you apply for trophy hunting permits for leopards?.....

How many have you had in the last five years?

How much do they cost?.....

How easy are they to obtain?

If difficult why?.....

How would you like to see the process of trophy hunting improved?

How many trophy hunts have been successful on your property?.....

How do you account for this success rate?.....

If you do not have trophy hunting on your property, why not?

Problem leopards

Have you ever hunted a problem leopard on your land?

Did you obtain a permit for this?

.....

How easy are these permits to

obtain?.....

How would you like to see the process of dealing with problem leopards improved?

Local leopard hunting

Do any of your neighbours hunt leopards? Please give details of this.....

Have you heard of any local poaching of leopards? Please give details of this.....

Conservation of leopards

Do you think leopards are a problem animal or an economic resource?.....

Should leopards be conserved in South Africa?

Yes/No

Please explain your reasons for this.....

Appendix 2. Consent form

TITLE OF PROJECT:

Leopard populations, sport hunting and conservation in the Soutpansberg Mountains

*Please cross out
as necessary*

Have you read the Participant Information Sheet? YES / NO

Have you had an opportunity to ask questions and to discuss the study? YES / NO

Have you received satisfactory answers to all of your questions? YES / NO

Have you received enough information about the study? YES / NO

Who have you spoken to? Dr/Mr/Mrs/Ms/Prof.

Do you consent to participate in the study? YES / NO

Do you understand that you are free to withdraw from the study:

* at any time and

* without having to give a reason for withdrawing and

* without any adverse result of any kind?

YES / NO

Signed **Date**

(NAME IN BLOCK LETTERS)

Signature of witness **Date**

(NAME IN BLOCK LETTERS)

Appendix 3a.

Capture histories of individually identified leopards photographed in the Soutpansberg Mountains, South Africa on 63 sampling occasions from 20th March – 21st May 2008 in the first camera trapping survey

[illegible]

Appendix 3b.

Capture histories of individually identified leopards photographed in the Soutpansberg Mountains, South Africa on 63 sampling occasions from 1st August – 2nd October 2008 during the second camera trapping survey

[illegible]

Appendix 4a.

SECR Input file 1 – Animal capture details

LOC_ID	ANIMAL_ID	SO
2	4	2
1	5	3
13	10	3
11	12	9
9	14	9
11	13	9
6	2	10
1	2	11
2	2	12
10	7	12
2	4	15
6	2	17
3	8	17
6	2	18
9	12	18
6	2	19
8	10	19
11	12	19
3	3	22
10	12	22
9	12	25
9	12	27
4	1	28
3	1	30
6	2	30
10	10	30
13	11	30
4	2	31
3	3	33
1	5	33
1	5	35
10	10	38
13	11	38
11	6	39
3	10	39
13	1	40
3	10	40
9	12	40
2	4	41
10	7	42
4	1	43

LOC_ID	ANIMAL_ID	SO
3	3	45
9	7	45
3	8	45
10	9	45
2	10	45
9	12	45
10	7	46
5	10	46
4	2	47
2	4	47
4	9	47
13	11	47
10	12	48
11	6	50
13	10	51
2	2	52
10	10	52
4	1	53
9	12	54
1	5	55
9	12	56
2	4	58
3	3	59
9	12	59
11	12	60
10	12	61
4	1	62
2	2	63

Appendix 4b.

SECR Input file 3 – Home range centres data

X_COORD	Y_COORD	HABITAT
29.40298	-23.1217	1
29.41831	-23.1212	1
29.43317	-23.1212	1
29.4485	-23.1217	1
29.46383	-23.1217	1
29.47962	-23.1212	1
29.49355	-23.1212	1
29.50935	-23.1212	1
29.52467	-23.1212	1
29.38733	-23.1054	0
29.40322	-23.1054	1
29.41794	-23.1066	1
29.43383	-23.1054	1
29.44913	-23.1054	1
29.46384	-23.106	1
29.47797	-23.1054	1
29.49327	-23.1066	1
29.50975	-23.106	1
29.52387	-23.106	1
29.53918	-23.1066	1
29.55683	-23.1066	1
29.37262	-23.0901	1
29.38851	-23.0907	0
29.40322	-23.0907	0
29.41911	-23.0907	0
29.43441	-23.0913	0
29.44855	-23.091	1
29.46502	-23.091	1
29.47914	-23.091	1
29.49326	-23.0904	1
29.51091	-23.091	1
29.52503	-23.0916	1
29.53973	-23.0904	1
29.5568	-23.0904	1
29.57209	-23.0904	1
29.35677	-23.0763	0
29.37383	-23.0751	1
29.38854	-23.0763	1
29.40384	-23.0763	1
29.41854	-23.0757	1
29.43325	-23.0757	1
29.44972	-23.0751	1

X_COORD	Y_COORD	HABITAT
29.46443	-23.0757	0
29.47855	-23.0751	1
29.49385	-23.0757	1
29.50855	-23.0763	1
29.52503	-23.0763	1
29.53973	-23.0757	1
29.55621	-23.0751	1
29.56915	-23.0768	1
29.35736	-23.0627	1
29.37148	-23.0604	1
29.38736	-23.0604	1
29.40207	-23.0604	1
29.41854	-23.0598	1
29.43266	-23.0616	1
29.44914	-23.0604	1
29.46502	-23.0616	1
29.47855	-23.061	0
29.49561	-23.061	1
29.51032	-23.0604	1
29.52503	-23.061	1
29.54032	-23.061	1
29.55621	-23.0604	1
29.57091	-23.0604	0
29.58503	-23.0616	0
29.35736	-23.0451	1
29.37325	-23.0451	1
29.38854	-23.0451	1
29.40384	-23.0463	1
29.41737	-23.0457	1
29.43384	-23.0451	1
29.44972	-23.0457	1
29.46443	-23.0463	1
29.47855	-23.0451	1
29.49444	-23.0457	1
29.50914	-23.0451	1
29.52385	-23.0468	0
29.54032	-23.0468	1
29.55503	-23.0445	1
29.57091	-23.0457	1
29.5868	-23.0451	1
29.35677	-23.031	1
29.37207	-23.0304	1
29.38795	-23.0304	1
29.40325	-23.0304	1
29.41972	-23.031	1
29.43384	-23.0304	1

X_COORD	Y_COORD	HABITAT
29.44914	-23.031	1
29.46443	-23.031	1
29.47914	-23.0316	1
29.49502	-23.0304	1
29.50973	-23.031	1
29.52503	-23.0321	1
29.54032	-23.0298	1
29.55621	-23.0298	1
29.56915	-23.0304	1
29.58562	-23.0304	1
29.35795	-23.0145	1
29.37383	-23.0145	1
29.38913	-23.0157	1
29.40384	-23.0157	1
29.41972	-23.0151	1
29.43443	-23.0151	1
29.44796	-23.0151	1
29.46326	-23.0157	1
29.4809	-23.0157	1
29.49385	-23.0145	1
29.50914	-23.0151	1
29.52503	-23.0157	1
29.54091	-23.0157	1
29.55562	-23.0151	1
29.5715	-23.0145	1
29.5868	-23.0157	1
29.35677	-23.0004	1
29.37266	-22.9998	1
29.38913	-22.9998	1
29.40266	-23.0004	1
29.41854	-22.9998	1
29.43325	-23.0004	1
29.44737	-22.9998	1
29.46384	-22.9998	1
29.47796	-22.9998	1
29.49502	-22.9992	1
29.51091	-23.0004	1
29.52385	-22.9992	1
29.54032	-23.001	1
29.55444	-22.9992	1
29.56974	-23.0004	1
29.5868	-22.9998	1
29.35618	-22.9845	1
29.37266	-22.9845	1
29.38854	-22.9845	1
29.40325	-22.9845	1

X_COORD	Y_COORD	HABITAT
29.41913	-22.9845	1
29.43325	-22.9839	1
29.44796	-22.9839	1
29.46502	-22.9851	1
29.4809	-22.9857	1
29.49561	-22.9839	1
29.51032	-22.9845	1
29.52503	-22.9851	1
29.53915	-22.9839	1
29.55621	-22.9839	1
29.5715	-22.9839	1
29.37383	-22.9698	1
29.38972	-22.9698	1
29.40325	-22.9692	1
29.41796	-22.9686	1
29.43384	-22.9704	1
29.44972	-22.9692	1
29.46384	-22.9698	1
29.47855	-22.9698	1
29.49502	-22.9686	1
29.50973	-22.9698	1
29.52562	-22.9692	1
29.54032	-22.9692	1
29.55562	-22.9698	1
29.57033	-22.9692	1
29.37383	-22.9539	1
29.38736	-22.9545	1
29.40443	-22.9539	1
29.41796	-22.9533	1
29.43443	-22.9545	1
29.44972	-22.9545	1
29.46502	-22.9539	1
29.47855	-22.9539	1
29.49561	-22.9533	1
29.51091	-22.9539	1
29.52503	-22.9545	1
29.54032	-22.9551	1
29.55503	-22.9539	1
29.38736	-22.9386	1
29.40325	-22.9386	1
29.41913	-22.9386	1
29.43384	-22.9392	1
29.44796	-22.938	1
29.46326	-22.9386	1
29.47973	-22.9386	1
29.49385	-22.9392	1

X_COORD	Y_COORD	HABITAT
29.5115	-22.9386	1
29.52562	-22.9386	1
29.54209	-22.9392	1
29.40384	-22.9239	0
29.41913	-22.9245	0
29.43502	-22.9233	0
29.45031	-22.9239	0
29.46502	-22.9233	1
29.47914	-22.9233	1
29.49502	-22.9245	1
29.50973	-22.9245	1
29.52562	-22.9239	1
29.43325	-22.9086	0
29.44972	-22.9086	0
29.46326	-22.9086	0
29.47914	-22.9086	0
29.49385	-22.9086	0
29.50973	-22.9092	0

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